Bapco Modernization Program

Environmental and Social Impact Assessment

Final Report

Prepared by:
Environment Arabia
Consultancy Services W.L.L

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Office 901, 9th Floor, The Address Tower
P.O. Box 10379
AlSeef Area
Kingdom of Bahrain
Tel: +973 1753 3259
Fax: +973 1753 3754
info@environmentarabia.com

Environment Arabia

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Authors	Andy Booth, Sarah Ben Arfa, Kate Elsworth, Rob Pierce, Matt Edwards

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Table of Abbreviations

AADT	Annual Average Daily Traffic
AAMR	Agriculture Affairs & Marine Resources
AAP	Area Action Plan
AC	Activated Carbon
ACM	Asbestos Containing Material
AEWRD	Agriculture, Engineering & Water Resources Directorate
Alba	Aluminium Bahrain
ALS	Australian Laboratory Services
AOD	Above Ordnance Datum
AOI	Area of Influence
APHA	American Public Health Association
API	American Petroleum Institute
AQMS	Air Quality Monitoring Station
ARU	Amine Regeneration Unit
BACA	Bahrain Authority for Culture & Antiquities
BAGRU	Bulk Acid Gas Removal Unit
Banagas	Bahrain National Gas
BaP	Benzo(a)pyrene
Bapco	Bahrain Petroleum Company
BAT	Best Available Techniques
BATc	BAT Conclusions
BAT-AELS	BAT Associated Emissions Levels
BD	Bahraini Dinars
BES	Bahrain Environment Society
BFW	Boiler Feed Water
bgl	Below Ground Level
BMP	Bapco Modernization Program
BOD	Biochemical Oxygen Demand
bpd	Barrels Per Day
BPIP	Building Profile Input-Program
BSIE	Bahrain Temperature Standard
BTEX	Benzene, Toluene, Ethyl benzene and xylenes
CCC	Criterion Continuous Concentration
CCME	Canadian Council of Ministers of the Environment
CDD	Civil Defence Directorate
CDU	Crude Distillation Unit
CEFAS	Centre for Environment, Fisheries & Aquaculture, UK
CEM	Continuous Emissions Monitoring
CEMP	Construction Environmental Management Plan
CESMP	Construction Environmental and Social Management Plan
CG	Coast Guard
CGRU	Crude Gas Recovery Unit
CH_4	Methane
CMC	Criteria Maximum Concentration
CO	Carbon Monoxide
COD	Chemical Oxygen Demand
CP	Corrosion Protection

CPO	Central Planning Office
CR	Critically Endangered
CRTN	Calculation of Road Traffic Noise
CSR	Corporate Social Responsibility
CSS	Contaminated Stormwater Sewer
CTRL	Channel Tunnel Rail Link
CW	Cooling Water
dB(A)	Decibel A-Weighted
DBT	Dibutyltin
DDV	Drop Down Video
DEA Unit	Diethanolamine Unit
Defra	Department of Environment, Food and Rural Affairs
DERM	Department of Environment and Resource Management (Australia Government)
DIAL	Differential Absorption Lidar
DMRB	Design Manual for Roads and Bridges
DoT	Department of Transport, UK
DOT	Dioctyltin
DPF	Diesel Particulate Filter
DRH	Diesel Range Hydrocarbons
DQRA	Detailed Quantitative Risk Assessment
EA	Environmental Assessment
EACS	Environment Arabia Consultancy Services
EBRD	European Bank of Reconstruction & Development
ECA	Export Credit Agencies
E-cat	Equilibrium Catalyst
ECM	Emissions Control Measures
EEE	Environmental Effects Evaluation
EER	Environmental Evaluation Report
EFOA	European Fuel Oxygenates Association
EHIA	Environmental Health Impact Assessment
EHS	Environmental Health and Safety
EIA	Environmental Impact Assessment
EII	Energy Intensity Index
ELV	Emission Limit Values
EMP	Environmental Management Plan
EMS	Environmental Management System
EPC	Engineering Procurement Contract
EPUK	Environmental Protection United Kingdom
EQC	Environmental Quality Criteria
EQO	Environmental Quality Objectives
EQS	Environmental Quality Standards
ESIA	Environmental and Social Impact Assessment
ESMS	Environmental and Social Management System
ESR	Environmental Scoping Report
EU	European Union
EU BREF	EU Best Available Techniques Reference Document
EWA	Electricity and Water Authority
FCCU	Fluid Catalytic Cracking Unit

FEED	Front End Engineering Design
GAN	Gaseous Nitrogen
GCC	Gulf Cooperation Council
GCU	Gas Concentration Unit
GDP	Gross Domestic Product
GDUP	General Directorate of Urban Planning
GHG	Greenhouse Gas
GIIP	Good International Industry Practice
GIS	Geographical Information Systems
GPIC	Gulf Petrochemical Industries Company
GRO	Gasoline Range Organics
GTU	Gas Treating Unit
H_2	Hydrogen
H_2S	Hydrogen Sulphide
H&S	Health & Safety
HAZID	Hazard Identification Study
HAZOP	Hazard Operability Study
HCU	Hydrocracker Unit
HCU PSA	Hydrocracker Unit Pressure Swing Adsorption Unit
HDU	Hydro-Desulphurisation Unit
HDU DEA	Hydro-Desulphurization Unit Diethanolamine Unit
HFO	Heavy Fuel Oil
HGV	Heavy Goods Vehicle
HLPH	High Lift Pump House
HRU	Hydrogen Recovery Unit
HTS	High Temperature Shift
IAF	Induced Air Flotation
IAQM	Institute of Air Quality Management
IBA	Important Bird Area
IEA	International Energy Agency
IEC	International Electrotechnical Commission
IED	Industrial Emissions Directive
IFC	International Finance Corporation
ILO	International Labour Organisation
IMO	International Maritime Organisation
IPPC	Integrated Pollution Prevention & Control
ISO	International Organisation for Standardisation
ISQG	Interim Marine Sediment Quality Guidelines
IUCN	International Union for Conservation of Nature
KGDU	Khuff Gas Desulphurisation Unit
KGSP	Khuff Gas Sweetening Plant
KMU	Kerosene Merox Unit
KSA	Kingdom of Saudi Arabia
L_{Aeq}	Equivalent continuous noise level
L_{den}	Day-evening-night equivalent noise level
L_{max}	Maximum Noise Level
LBO	Lubricating Base Oil
LBOP	Lubricating Base Oil Plant
LBOU	Lubricating Base Oil Unit

LDAR	Leak Detection and Repair
Li	Limited Area
LIN	Liquid Nitrogen
LLPH	Low Lift Pump House
LNAPL	Light Non-Aqueous Phase
Lo	Local Area
LPG	Liquefied Petroleum Gas
LSDP	Low Sulphur Diesel Production
LSFO	Low Sulphur Fuel Oil
LSFO PSA	Low Sulphur Fuel Oil Pressure Swing Adsorption Unit
LT	Long-term (over 10 years)
LTS	Low Temperature Shift
MARPOL	International Convention for the Prevention of Pollution from Ships
MBT	Monobutyltin
MEBR	Marine Environment Baseline Report
MEBS	Marine Environment Baseline Survey
MED	Multi-Effect Distillation
MMAUP	Ministry of Municipalities Affairs & Urban Planning
MPA	Marine Protected Area
MPht	Monophenyltin
MPZ	Marine Policy Zone
MoTT	Ministry of Transport & Telecommunications
MOT	Monooctyltin
MT	Mid-term (5 to 10 years)
MTBE	Methyl Tert-Butyl Ether
MSDS	Material Safety Data Sheet
MSF	Multi-Stage Flash
MSP	Marine Spatial Plan
NAGD	Australian Government National Assessment Guidelines for Dredging
NAPM	National Environment Protection Measures
NEA	Nautica Environmental Associates
NMC	National Maritime Centre
NMVOC	Non-Methane Organic Compounds
NO	Nitrogen Oxide
NOx	Nitrogen Oxides
NOGA	National Oil and Gas Authority
NORM	Naturally Occurring Radioactive Materials
NPDS	National Planning Development Strategy
NPL	National Physics Laboratory, UK
NRC	Naptha Rerun Complex
NRMM	Non-Road Mobile Machinery
NTU	Nephelometric Turbidity Units
O_2	Oxygen
O_3	Ozone
OC	Officer in Charge
OECD	Organisation for Economic Cooperation and Development
OESMP	Operation Environmental and Social Management Plan
OGTU	Olefinic Gas Treatment Unit
OSCP	Oil Spill Contingency Plan

OWS	Oily Water Separator
PAH	Polyaromatic hydrocarbons
PC	Process Contribution
PCB	Polychlorinated Biphenyls
PEC	Predicted Environmental Concentration
PEL	Probable Effect Level
PEMS	Predictive Emissions Monitoring Program System
PIS	Project Information Sheet
$PM_{2.5}$	Particulate Matter up to 2.5 Micrometres in Size
PM_{10}	Particulate Matter up to 10 Micrometres in Size
PM	Passage Migrant/ Particle Matter
PMA	Ports & Maritime Affairs
PME	Presidency of Meteorology & Environment
POLY	Catalytic Polymerization Unit
PPAH	Pollution Prevention & Abatement Handbook
ppb	Parts Per Billion
ppm	Parts Per Million
PPE	Personal Protective Equipment
PPV	Peak Particle Velocity
PSA	Pressure Swing Adsorption/ Particle Size Analysis
PTS	Permanent Auditory Threshold Shift
QRA	Quantitative Risk Assessment
RAMSAR	The Convention on Wetlands of International Importance
RCC	Regional Coastal Cell
RECOFI	Regional Commission for Fisheries
RFG	Refinery Fuel Gas
RHCU	Residue Hydrocracking Unit
ROPME	Regional Organisation for the Protection of the Marine Environment
RPDD	Roads, Planning and Design Directorate
RRM	Risk & Reliability Based Maintenance
SABIC	Saudi Arabic Basic Industries Company
SCE	Supreme Council for Environment, Kingdom of Bahrain
SCR	Selective Catalytic Reduction
SCUBA	Self Contained Breathing Apparatus
SEA	Strategic Environmental Assessment
SEL	Sound Exposure Levels
SEPPD	Sanitary Engineering Projects & Planning
SIA	Social Impact Assessment
SIZ	Structure Influence Zone
SGP	Saturated Gas Plant
SHF	Sulphur Handling Facility
SNCR	Selective Non-Catalytic Reduction
SO_2	Sulphur Dioxide
SOF	Solar Occulation Flux
SOPEP	Ship Oil Pollution Emergency Plan
SPL	Sound Pressure Level
S-P-T	Source-Pathway-Target
SRU	Sulphur Recovery Unit
ST	Short-term (1 to 5 years)

STP	Sewage Treatment Plant
SU	Storage Unit
SWS	Sour Water Stripper
T&I	Turnover and Inspection
T	Temporary (less than 1 year)
TBC	To Be Confirmed
TBT	Tributyltin
TCyT	Tricyclohexyltin
TDS	Total Dissolved Solids
TeBT	Tetrabutyltin
TEL	Threshold Effect Level
TGTU	Tail Gas Treating Unit
TNMHC	Total Non Methane Hydrocarbons
TOC	Total Organic Carbon
TPH	Total Patroleum Hydrocarbons
TPhT	Triphenyltin
TPIT	Technip Italy
TSS	Total Suspended Solids
TTS	Temporary Auditory Threshold Shift
UER	*Rus-Umm Er Radhuma*
UNESCO	United Nations Educational Scientific and Cultural Organisation
US EPA	United States Environment Protection Agency
US GPM	United States Gallons Per Minute
VBU	Visbreaking Unit
VDU	Vacuum Distillation Unit
VDV	Vibration Dose Value
VGO	Vacuum Gas Oil
VOC	Volatile Organic Compound
VU	Vulnerable
WBG	World Bank Guidelines
WHO	World Health Organisation
WoRMS	World Register of Marine Species
WP	Work Packages
WQO	Water Quality Objectives
WWTP	Waste Water Treatment Plant

Environment Arabia

1 INTRODUCTION

1.1 Background

Environment Arabia Consultancy Services WLL (EACS) has been appointed by Technip Italy S.p.A to undertake an Environmental and Social Impact Assessment (ESIA) for the Bapco Modernization Program (BMP) project. The BMP comprises a package of developments to update and expand the capacity of the Refinery, to modernize it and make it more cost competitive.

The main elements of the BMP will be located to the south and east of the existing process units. The BMP will involve the construction of several new process units and auxiliary plants and also revamps some existing process facilities. The BMP will replace the oldest and least efficient existing process units at the Refinery and operate alongside the remaining viable units. The BMP will also require changes and development of Sitra Tank Farm, Sitra Wharf and the transfer pipelines between the Refinery and the Sitra facilities.

This document is the ESIA Report. It follows the Environmental Screening (EA-2 Form) and ESIA Scoping Reports submitted to the Supreme Council for Environment (SCE) in August and December 2015 respectively. This study presents the environmental baseline conditions of the project area and identifies potential impacts of the project on the surrounding environment during both the construction and operation phases.

1.2 Scope of ESIA

This ESIA has been undertaken as part of the Front End Engineering Design (FEED) for the project and as such the information upon which this ESIA is based may change in future stages of the project. It is the responsibility of the project proponent to update the Government stakeholders concerned regarding any changes, and for updating the ESIA where required, once the ESIA has been completed and submitted.

1.3 Statement of Need

1.3.1 Refinery Efficiency and Competiveness Improvements

The Refinery began operations in 1936, and has since been periodically upgraded with new units. The Refinery currently has a constrained output which includes low value, low demand products which could put it at a competitive disadvantage in the future.

The new Refinery configuration post-BMP, would allow for higher throughput, improved product quality and ensure Bapco's continued competitiveness under a wide range of process and market scenarios. A preliminary assessment carried out for the BMP established that the most effective way of improving gross margin is to concentrate on middle distillates production such as diesel and kerosene.
The strategic objectives for BMP are:

- Refinery Configuration and Gross Margin – A revised configuration shall allow for higher throughput, improve the product slate and increase gross margin with the objective to remain competitive under a wide range of prices and market scenarios.

- Energy Efficiency – The BMP shall improve energy efficiency and lower the Energy Intensity Index (EII) of the Refinery by installing energy efficient new crude and process units. This shall also have a positive impact on reduction of carbon release per barrel processed.

- Environmental Compliance – All new units shall function in compliance with applicable local environmental regulations.

The scope of the BMP comprises:

- Optimization of crude capacity.
- Upgrade process residues and reduce or eliminate fuel oil production.
- Increase middle distillates production.
- Improve energy efficiency.
- Meet all Bapco and Bahrain Government applicable environmental regulations.
- Comply with future gasoline and diesel specification (Euro 5).
- Comply with future bunker fuel oil specification as per the International Maritime Organization (IMO).

It is noteworthy that there are two additional strategic projects within the oil and gas sector in the Kingdom of Bahrain tied in with the BMP. These are the new A/B (Arabia-Bahrain) pipeline and the NOGA Terminal Platform. The new A/B pipeline will be designed to accommodate 350,000 – 400,000 barrels per day (bpd) to convey crude oil from Saudi Arabia to the Bapco Refinery. The NOGA Terminal Platform will be reclaimed to the north of the existing GPIC development (north of the Refinery) and will provide storage facilities for middle distillate petroleum products that will be generated by the BMP. Both these projects have been subject to the national environmental permitting process and have obtained environmental permits.

1.3.2 Introduction of MTBE Containing Gasoline to Bahrain

Part of the BMP is the upgrade of Sitra Wharf and Sitra Tank Farm facilities to allow for the importation of MTBE-containing gasoline and importation of neat MTBE for blending into gasoline by Bapco. This will allow for MTBE blended fuels to be released for use in vehicles in the local Bahrain market. This should have a significant positive impact on air quality in Bahrain at a national level.

Vehicle emissions are responsible for a significant fraction of air pollution in urban areas. MTBE is an octane booster and a fuel oxygenate and its use allows for more complete combustion of gasoline by vehicle engines. Consequently the rate of emissions of air pollutants from vehicles is reduced.

Bapco intend to import MTBE and blend it with gasoline at concentrations of up to 15% for supply to the Bahrain market. Use of MTBE in gasoline is reported to have the following effects on vehicle emissions and urban air quality[1] (EFOA, 2006);

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[1] MTBE Resource Guide 2nd Revision, April 2005 (as amended February 2006), the European Fuel Oxygenates Association.

- 20-25% reduction in carbon monoxide emissions;
- 10-15% reduction in unburnt hydrocarbon emissions;
- 30% reduction in particulate matter emissions;
- 20-30% reduction in benzene emissions;
- 5% reduction in nitrogen oxide emissions; and
- Reduction in ground level ozone concentration.

It is expected that importation and use of MTBE gasoline in Bahrain will allow the implementation of new legislation to require passenger cars to meet EU emissions specification Euro 4 or 5.

1.4 Consideration of the ‘Do Nothing’ Option

Bapco is an important contributor to modern Bahrain, accounting for a significant portion of the region’s energy-related activities. The Refinery currently produces 267,000 bpd, refining all the crude generated from the Bahrain Field in addition to the crude oil imported through the A/B pipeline. 95% of Bapco’s products are exported which contributes significantly to the country’s gross domestic product.

A significant number of jobs are provided for the local population and employees undergo specific job-related training and development. Bapco is a Corporate Social Responsibility (CSR) pioneer in Bahrain, contributing millions of dollars annually in supporting a multitude of projects, sporting events, educational schemes and business events.

As discussed above, the Refinery currently has a constrained output which includes low value, low demand products which could put it at a competitive disadvantage in the future. The BMP is an essential project, required to ensure the future of this important and only refinery in Bahrain.

1.5 The Client

Bapco was established by the standard Oil Company of California in 1929, prior to the discovery of oil in 1932. Since that time, Bapco has been a leading contributor to the national economy as an integrated gas and oil company, engaging in oil and gas exploration, refining, production and marketing of petroleum finished products: middle distillates, lubricating base oil (LBO) and other refined products.

Currently, Bapco owns a 267,000 barrel-a-day refinery, storage facilities for 14 million barrels, a marketing terminal and a marine terminal for its petroleum products. About one-sixth of this crude originates from the Bahrain Field, with the remainder being pumped from Saudi Arabia through the A/B Pipeline. 95% of Bapco's refined products are exported. Utilising advance techniques, Bapco also carried out extensive studies to obtain accurate data on existing oil and gas reserves.

1.6 ESIA Consultants

1.6.1 Environment Arabia Consultancy Services

EACS is an Environmental Consultancy based in Bahrain offering a full range of environmental consultancy services to clients in sectors including: mixed use development; oil and gas; petrochemicals; ports and maritime; power generation; reclamation and dredging; sewage treatment; steel and aluminum manufacture; transport and waste to energy. These services have been provided across the Arabian Gulf including Bahrain, Kuwait, Oman, Saudi Arabia, Dubai, Abu Dhabi, Sharjah, Ajman, Qatar and Jordan.

The company has been established since the year 2000 and was the first registered environmental consultancy with the Supreme Council for Environment (SCE) under Ministerial Order No. 3 with respect to the Environment Authority's recognition of consulting firms involved in the field of environmental evaluation of projects and environmental studies.

The team of specialists from EACS is presented in **Table 1.1**.

Table 1.1 EACS's ESIA Project Team

Name	Role Within Project
Halel Engineer	Project Director, ESIA and Local Specialist
Andy Booth	Technical Director & Project Manager, Contaminated Land, Waste and Soil & Groundwater Specialist
Michael Arora	Technical Director - Marine Ecology, Water Quality, Sediment Quality, Hydrodynamics
Kate Elsworth	ESIA Specialist
Richard Hardeman	Senior Environmental Consultant, Air Quality and Noise, Contaminated Land
Sarah Ben Arfa	Senior Marine Consultant, Marine Ecology, Water Quality, Sediment Quality, Hydrodynamics
Eman Rafea	Environmental Consultant, ESIA Specialist, Stakeholder Consultation
Christopher Nacional	GIS/Mapping Specialist

1.6.2 Subconsultants

EACS has been supported by the following external specialists.

Royal Haskoning DHV UK - Air Quality Assessment

Royal Haskoning DHV is an independent, international engineering and project management consultancy with over 130 years of experience. The UK air quality team sits in a 100-strong Environment & Infrastructure Consenting service business unit which has been an active forerunner in pre- and post- application environmental support across a number of industries. There is a well-established and historical relationship between Haskoning DHV and EACS and several projects have been undertaken in partnership in the past: air quality modelling and impact assessment services were provided for a number of ESIA projects in Bahrain, and elsewhere in the Middle East such as the Khuff Gas Development Program ESIA, Bapco Refinery Gas Desulphurisation Project ESIA and the Lube Base Oil Project.

Tree Environmental - Noise Assessment

Rob Peirce is Director of Tree Environmental who are noise, vibration and air quality consultants based in the UK. He has over 26 years experience in noise and vibration, the last 23 as an acoustics consultant. Rob has provided noise and vibration advice on many major schemes such as the Channel Tunnel Rail Link (CTRL) which included a review of noise and vibration issues including the prediction methodology, standards/criteria and assessment methodology for the proposed CTRL. Other significant schemes/projects that have required noise and vibration advice include the 2012 London Olympic ESIA for both the original application (2003) and the Stadium Legacy Transformation (2012), Defra research for a Night-time Noise Nuisance (which is now on the statute books in UK), CrossRail, Liverpool Airport expansion, Wembley Stadium, relocation of Arsenal Football Club to Ashburton Grove, Bristol University and Leeds Supertram. Rob has provided evidence at Public Inquiries for many of these schemes.

Acoustic assessments have ranged from initial feasibility studies to detailed acoustic design to minimise noise breakout and transmission to both adjacent and surrounding properties. The assessments considered the sound insulation performance of the structure, the noise impact of mechanical services plant, inspections and acoustic specifications for both refurbishment and 'new build' schemes. Overseas projects include the design of acoustic aspects of an Auditorium, Training Centre, Executive offices and conference rooms for the SABIC HQ in Saudi Arabia, noise and vibration measurements and modelling from the Abu Dhabi Grand Prix circuit and environmental projects including the N-Road and Al Fateh Highway Bahrain and petrochemical plant noise.

HR Wallingford - Hydrodynamic Modelling

HR Wallingford is an independent civil engineering and environmental hydraulics organisation. With a 65 year track record of achievement, their unique mix of know-how, assets and facilities includes state of the art physical modelling laboratories, a full range of numerical modelling tools and experts with world-renowned skills and expertise. HR Wallingford has Scientific Research Association status. They are a company limited by guarantee run by a panel of Company Members from UK-based organisations, government departments and agencies related to the industry. They have extensive experience of working in the Kingdom of Bahrain, having collaborated with EACS, amongst others, on the Saudi-Bahrain Rail Link ESIA project, Muharraq STP ESIA, South Alba STP ESIA, and the Bapco Cooling Water Intake modelling study.

Al Reem Environmental Consultation and Ecotourism - Terrestrial Ecology and Infaunal Identification

Dr Saeed Alkhuzai is the General Manager of Al Reem Environmental Consultation and Ecotourism. He is a prominent figure in Bahrain in the field of ecological assessment and protection with over 40 years' experience. He is a Member of the IUCN Commission on Protected Areas, Chairman of the Bahrain Natural History Society and a BirdLife International Representative. In addition he is a Member of the Regional Training Board for Wings on Wetlands and an Advisor (Natural Heritage) for the Bahrain UNESCO Team, World Heritage Committee.

Al Reem also has provided environmental consultancy service to Bapco in a number of environmental programs.

Nautica Environmental Associates L.L.C (NEA) - Statistical Analysis of Infaunal Data

NEA is an Abu Dhabi based environmental consultancy established in 2005, who as part of the marine environmental baseline survey works, undertook the statistical analysis of the infaunal data. EACS has collaborated with NEA on numerous projects and over the last decade.

Australian Laboratory Services (ALS) – Soil, Sediment and Water Quality Analysis

Soil, seawater and marine sediment samples were collected and subsequently analysed for a range of parameters. The testing was undertaken by Australian Laboratory Services (ALS) based in the Kingdom of Saudi Arabia (KSA). ALS is one of the world's largest and most diversified testing services providers and is certified to ISO/IEC 17025:2005, General Criteria for the competence of Testing and Calibration Laboratories.

Al Hoty Analytical Services – Marine Sediment Quality Analysis

Al Hoty is based in the Kingdom of Bahrain and undertook additional sediment quality analyses to support the marine environmental baseline study. Al Hoty is certified to ISO/IEC 17025:2005. Al Hoty also is an approved and registered contractor of Bapco.

1.7 ESIA Report Structure

Reporting of the ESIA comprises four main documents:

i. Environmental and Social Impact Assessment Report (this report);
ii. Construction Environmental and Social Management Plan (CESMP);
iii. Operation Environmental and Social Management Plan (OESMP);
iv. Non Technical Summary (in Arabic and English).

This report, the ESIA contains the following sections:

1. Introduction
2. Project Description
3. Landuse and Planning
4. ESIA Methodology
5. Stakeholder Engagement
6. Air Quality
7. Soil and Groundwater
8. Noise
9. Hydrodynamics and Water Quality
10. Sediment Quality
11. Marine Ecology
12. Terrestrial Ecology and Avifauna
13. Cultural Heritage and Archaeology
14. Traffic and Access
15. Waste
16. Chemicals
17. Energy Efficiency
18. Social and Community Impacts

19. Labour and Working Conditions
20. Occupational Health and Safety
21. Environmental Management and Mitigation

2 PROJECT DESCRIPTION

2.1 Location

The main elements of the BMP will be located in the vicinity of the existing Refinery, although the BMP will also require changes and development of Sitra Tank Farm, Sitra Wharf and the transfer pipelines between the Refinery and Sitra facilities. **Figure 2.1** shows the full extent of the BMP including land proposed for use as construction laydown areas and labour camps.

2.1.1 Bapco Refinery Site

The Refinery is located adjacent to the Arabian Gulf. The Refinery site is approximately 480 hectares including operational and non-operational land and the so called "Pitch Ponds" site. The land immediately adjacent to the Gulf is very low lying at approximately 1-3 m AOD. Moving to the north and east away from the Gulf, the land level rises gradually to a maximum elevation of 14 m at the west of Sitra Tank Farm before falling away steeply to the west to around 2-3 m AOD. The main existing process area is located in the central area of the site. The BMP plant will be located on the former Pitch Ponds to the west of the existing process units as well as on land to the east of the existing plant.

2.1.2 BMP Site

The BMP units will be mainly located on the former Pitch Ponds. These were originally used to dispose or store pitch which was a by-product from the refinery process. In its original configuration, between 1941 and 1945, the Refinery produced pitch which was deposited on low lying land to the west of the Refinery which became known as the Pitch Ponds. From 1945 onwards, pitch was deposited from time to time as improvements to the Refinery meant that there was no requirement to routinely discharge pitch.

During the 1990s the Pitch Ponds site was occupied by AGAS International who set up a 300,000 tonne per year capacity plant to recover and recycle the pitch for use in fuel oil manufacture. The majority of the pitch has now been recovered from the site and the land is due to be returned to Bapco who will use the bulk of this land for the BMP. The Pitch Ponds site now comprises mainly open, flat land and the surface soil layers contain some residual pitch contamination.

AGAS remain operational in the western part of the site and several large Pitch Ponds remain which contain liquid pitch that AGAS is continuing to process. Further west beyond the remaining Pitch Ponds is the AGAS processing plant and storage tanks. Before construction of the BMP commences, AGAS will have completed the recovery of liquid pitch and the AGAS facility will have been decommissioned and demolished by AGAS.

2.1.3 Transfer Lines, Sitra Tank Farm and Wharf

Sitra Tank Farm and Sitra Wharf are located at the south of Sitra Island. Transfer lines pass products between the Refinery and Sitra Tank Farm over Ma'ameer Channel. All of these facilities are situated on relatively flat, low lying land.

To the east of Sitra Tank Farm and north of Sitra Wharf a new terminal is planned to be constructed. This project is being led by the National Oil and Gas Authority (NOGA). NOGA already has planning permission to reclaim the site from the sea and this work is underway.

2.2 Process and Capacity Change

The Refinery at Sitra was constructed in 1936 with an initial production capacity of about 10,000 bpd. Over the years the Refinery has been developed and expanded to a capacity of 267,000 bpd.

The BMP will increase the capacity of the Refinery still further to 360,000 bpd. A range of products will be produced: naptha, gasoline, kerosene, diesel, fuel oil, lubricating oil, asphalt, LPG and sulphur.

The BMP is designed to concentrate production on middle distillates. The BMP will not increase fuel oil production capacity and will include additional process steps to convert fuel oil fractions to middle distillate products. The quantity of gasoline produced will not change.

2.3 Process Unit Operation Changes

The BMP will involve the construction of several new process units and auxiliary plant and also revamp some of the existing process facilities. The BMP will replace the oldest and least efficient existing process units at the Refinery and operate alongside the remaining viable units. The process changes to be introduced by the BMP are summarised in **Table 2.1**. **Figure 2.2** shows the proposed locations for the new process units and indicates the existing process units that will be decommissioned.

The modernization will include the staged implementation of at least six main process units, including: a new crude distillation unit; a new vacuum distillation unit; a residue hydrocracker; vacuum gas oil hydrocracker; diesel hydro-desulphurization unit and sulphur recovery unit. Additional process units will also be required to produce hydrogen and manage process gases.

Title: **Site Location and Project Components**		Client: Bapco Technip
Project: Bapco Modernization Program		
Date: June 2016	Figure No.: 2.1	Consultant: Environment Arabia
Datum: WGS 84 - UTM 39N	Scale: 1:50,000 (A4)	

CN:\Bapco Modernisation Plan\mxd\2.1 Site Location wo LD.mxd

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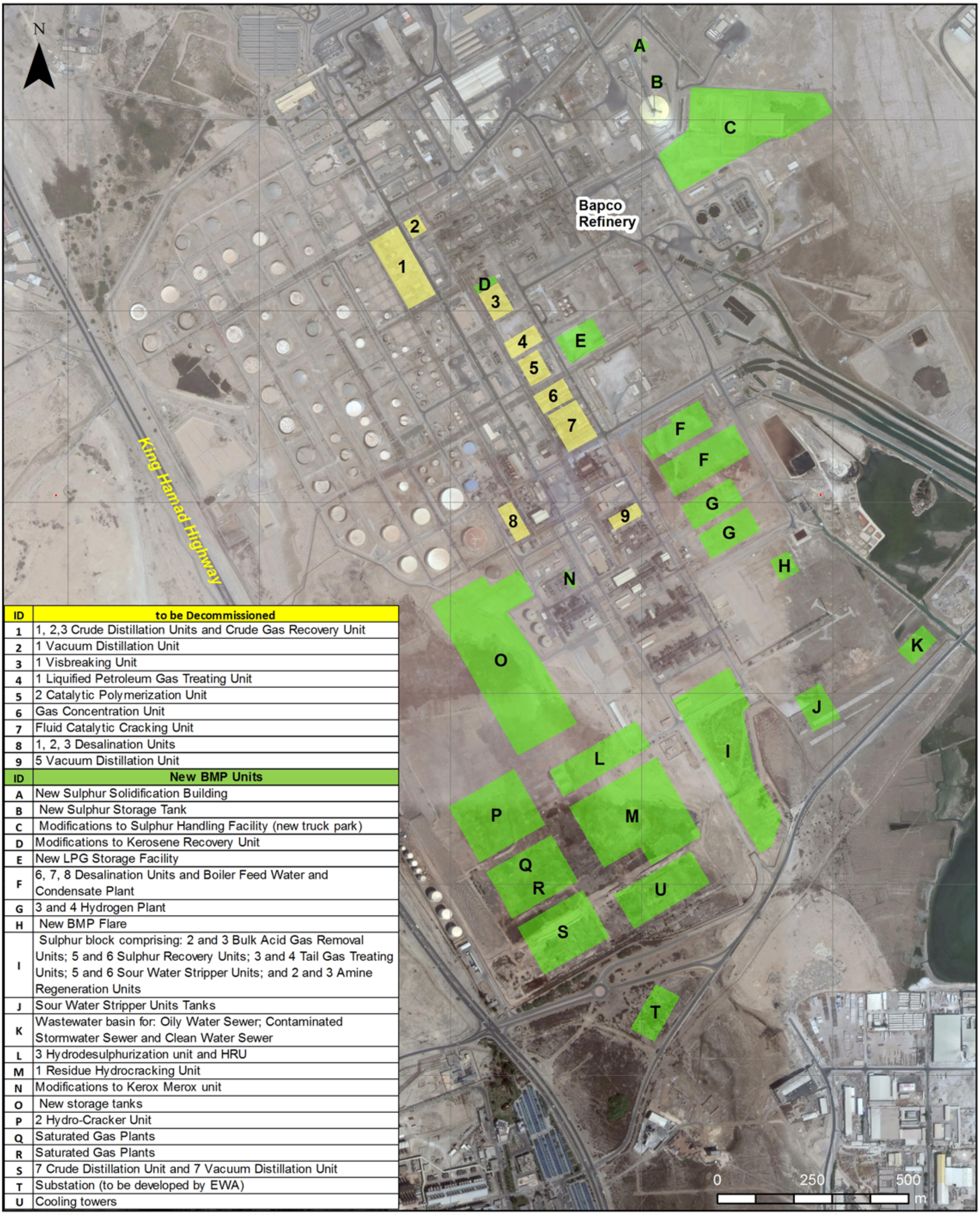
Table 2.1 BMP Inventory of New, Retained and Decommissioned Process Units

Unit	Name	Function
NEW BMP PROCESS UNITS		
7CDU	Crude Distillation Unit	Distills crude oil into fractions at atmospheric pressure
7VDU	Vacuum Distillation Unit	Further distills residual heavy fractions under vacuum after crude distillation stage
1RHCU	Residue Hydrocracking Unit	Treats heavy fractions from VDU using hydrogen to upgrade heavier fractions into lighter, more valuable products
2HCU	Vacuum Gas Oil (VGO) Hydrocracker Unit	Uses hydrogen to upgrade heavier fractions into lighter, more valuable products e.g. diesel, kerosene
3HDU	Hydro-Desulphurization Unit	Diesel hydro-desulphurization unit
3 & 4 H2 Plant	Hydrogen Production Plants	Produces hydrogen to supply certain processes
1KMU	Kerox Merox Unit	Addition of one extra train to the existing KMU)
New SGP	Saturated Gas Plant	To recover Liquified Petroleum Gas (LPG) and naptha from the Refinery off-gases
New HRU	Hydrogen Recovery Unit	To recover hydrogen from Refinery off-gases before feeding to the Saturated Gas Plant
New Auxillary Units		
2 & 3 BAGRU	Bulk Acid Gas Removal Units	Removes hydrogen sulphide from Khuff gas
5, 6 & 7 SRU	Sulphur Recovery Units	Strips sulphur from Refinery gases and converts it to elemental sulphur
3 & 4 TGTU	Tail Gas Treating Units	Treats waste gases from a number of Refinery processes
5 & 6 SWS	Sour Water Stripper Units	Removes sulphur from sour water from the TGTU and other Refinery processes
2 & 3 ARU	Amine Recovery Units	Removes hydrogen sulphide from Refinery off gases
New Desal	Desalination Plant	Provides desalinated water to the process
BMP Flare	BMP Flare	Flares off gas during periods of abnormal operation (e.g. start-up, shut-down, maintenance)
BFW	Boiler Feed Water	
SGU	Steam Generation Unit	HP boilers for steam generation and distribution
SHF	Sulphur Handling Facility	
C3/C4 SU	Storage Unit at Refinery	
C3/C4 SU	Storage Unit at Wharf	
UNITS TO BE DECOMMISSIONED		
Crude Distillation Units		
1CDU	Crude Distillation Unit	Distills crude oil into fractions at atmospheric pressure
2CDU	Crude Distillation Unit	As above
3CDU	Crude Distillation Unit	As above
Vacuum Distillation Units		
1VDU	Vacuum Distillation Unit	Further distills residual heavy fractions under vacuum after crude distillation stage
5VDU	Vacuum Distillation Unit	As above
FCC Complex		
FCCU	Fluid Catalytic Cracking Unit	Catalytic cracker to create lower molecular weight hydrocarbons from higher molecular weight refinery fractions

Unit	Name	Function
GCU	Gas Concentration Unit	Concentrates gas fraction from FCCU
2POLY	Catalytic Polymerization Unit	Liquefies C3 and C4 material from the FCCU and converts them into gasoline blending components
1LPG	Liquefied Petroleum Gas Treating Unit	Removes sour gas from catalytic naphtha products
NRC	Naphtha Rerun Complex	Splits naphtha into light and heavy fractions
Low Sulphur Fuel Oil (LSFO) Complex		
None		
Low Sulphur Diesel Production (LSDP) Complex		
None		
Other Units		
CGRU	Crude Gas Recovery Unit	Recovers off gas from CDUs for further refining
90C2	C2 Rerun Column	Splits naphtha into light and heavy fractions
GTU	Gas Treating Unit	Processes gas from GCU
1,2,3,4,5 Desal	Desalination Units	Provides desalinated water to the process
1VBU	Visbreaking Unit	Thermally cracks residual heavy fractions from distillation to create middle distillates
RHLF	Remote High Level Flare	Flares off vapors
UNITS TO BE RETAINED		
Crude Distillation Units		
4ACDU (atmospheric section)	Crude Distillation Unit Atmospheric Section	Distills crude oil into fractions at atmospheric pressure
4ACDU (vacuum section)	Crude Distillation Unit Vacuum Section	Distllls crude oil into fractions under vacuum
5CDU	Crude Distillation Unit	Distills crude oil into fractions at atmospheric pressure
Vacuum Distillation Units		
6VDU	Vacuum Distillation Unit	Distills crude oil into fractions at atmospheric pressure
FCC Complex		
OGTU	Olefinic Gas Treatment Unit	Removal of H2S from Refinery gas
FCCU Flare	FCCU Flare	Flares off vapors
Low Sulphur Fuel Oil (LSFO) Complex		
1H2 Plant	Hydrogen Production Plant	Generates hydrogen for use in Refinery processes
2HDU	Hydro-Desulphurization Unit	Catalytic desulphurization of diesel fraction
2HDU DEA Unit	Hydro-Desulphurization Unit Diethanolamine Unit	Removal of sulphur from diethanolamine into gas
3 & 4 SRU	Sulphur Recovery Units	Strips sulphur from Refinery gases and converts it to elemental sulphur
2TGTU	Tail Gas Treating Unit	Treats waste gases from a number of Refinery processes
3 & 4 SWS	Sour Water Strippers	Removes sulphur from sour water
LSFO PSA Unit	Low Sulphur Fuel Oil Pressure Swing Adsorption Unit	Recovery of hydrogen from process off-gas
Low Sulphur Diesel Production (LSDP) Complex		
1HCU	Hydrocracker Unit	Catalytic cracking of heavy end hydrocarbon fractions to create mid and low molecular weight fractions
2H2 Plant	Hydrogen Production Plant	Produces hydrogen from treated Khuff gas

Unit	Name	Function
HCU PSA Unit	Hydrocracker Unit Pressure Swing Adsorption Unit	Recovery of hydrogen from process off-gas
1ARU	Amine Recovery Unit	Removes hydrogen sulphide from Refinery off gases
1TGTU	Tail Gas Treating Unit	Treats waste gases from a number of Refinery processes
BAGRU	Bulk Acid Gas Removal Unit	Removes hydrogen sulphide from Khuff gas
1 & 2 SRU	Sulphur Recovery Unit	Strips sulphur from Refinery gases and converts it to elemental sulphur
1 & 2 SWS	Sour Water Stripper	Removes sulphur from sour water
Other Units		
LBOU	Lube Base Oil Unit	Creates lubricating oil fractions from hydrocracker unit bottom fractions
Unifiner Platformer	Unifiner Platformer	Catalytic process to convert naphtha to gasoline
1KMU	Kerosene Merox Unit	Removes sulphur compounds from kerosene
1KRU	Kerosene Recovery Unit	Removes sour gas from kerosene
SHF	Sulphur Handling Facility	Creates and handles solid sulphur
KGSP	Khuff Gas Sweetening Plant	Removal of H2S from Khuff gas



ID	to be Decommissioned
1	1, 2,3 Crude Distillation Units and Crude Gas Recovery Unit
2	1 Vacuum Distillation Unit
3	1 Visbreaking Unit
4	1 Liquified Petroleum Gas Treating Unit
5	2 Catalytic Polymerization Unit
6	Gas Concentration Unit
7	Fluid Catalytic Cracking Unit
8	1, 2, 3 Desalination Units
9	5 Vacuum Distillation Unit
ID	**New BMP Units**
A	New Sulphur Solidification Building
B	New Sulphur Storage Tank
C	Modifications to Sulphur Handling Facility (new truck park)
D	Modifications to Kerosene Recovery Unit
E	New LPG Storage Facility
F	6, 7, 8 Desalination Units and Boiler Feed Water and Condensate Plant
G	3 and 4 Hydrogen Plant
H	New BMP Flare
I	Sulphur block comprising: 2 and 3 Bulk Acid Gas Removal Units; 5 and 6 Sulphur Recovery Units; 3 and 4 Tail Gas Treating Units; 5 and 6 Sour Water Stripper Units; and 2 and 3 Amine Regeneration Units
J	Sour Water Stripper Units Tanks
K	Wastewater basin for: Oily Water Sewer; Contaminated Stormwater Sewer and Clean Water Sewer
L	3 Hydrodesulphurization unit and HRU
M	1 Residue Hydrocracking Unit
N	Modifications to Kerox Merox unit
O	New storage tanks
P	2 Hydro-Cracker Unit
Q	Saturated Gas Plants
R	Saturated Gas Plants
S	7 Crude Distillation Unit and 7 Vacuum Distillation Unit
T	Substation (to be developed by EWA)
U	Cooling towers

Title: **Locations of Units to be Decommissioned and New BMP Units to be Installed**

Project: Bapco Modernization Program

Date: June 2016

Figure No.: 2.2

Datum: WGS 84 - UTM 39N

Scale: 1:15,000 (A4)

Client: Bapco Technip

Consultant: Environment Arabia

CN:\Bapco Modernisation Plan\mxd\new units_decommission2.mxd

2.4 Process Description

The arrangement of the new BMP process units is shown in **Figure 2.3**. The first process sections – CDU and VDU - fractionate crude oil under atmospheric and vacuum conditions respectively. The atmospheric stage creates a range of middle distillate products (naptha, kerosene and diesel) that only require storage and blending. The vacuum stage maximises the recovery of middle distillate fractions from the crude oil feedstock. The remaining process stages use catalysis to maximise the yield of middle distillate products from heavier hydrocarbon fractions. The HCU and HDU also use hydrogen in addition to catalysis to generate lighter hydrocarbon fractions. The hydrogen will be generated on site in two hydrogen production units that will use Khuff gas as a feedstock.

All process elements, except the VDU, produce gaseous fractions that will be collected and fed to a new Saturated Gas Plant (SGP) that will fractionate the gas into propane (C3), butane (C4), light naptha and heavy naptha that will be sent for storage. The SGP will also produce sweet gas for use as process fuel.

Sulphur will be removed from process gases and effluents to create low sulphur refined products. The accumulated sulphur will be treated by Sulphur Recovery Units which create liquid sulphur which will then be solidified and pelletized to create an elemental sulphur by-product. There will be three trains which will produce 250 tonnes per day, giving a total of 750 tonnes. This sulphur will be sold.

2.5 Changes to Ancillary Units and Utilities

2.5.1 Electricity Supply

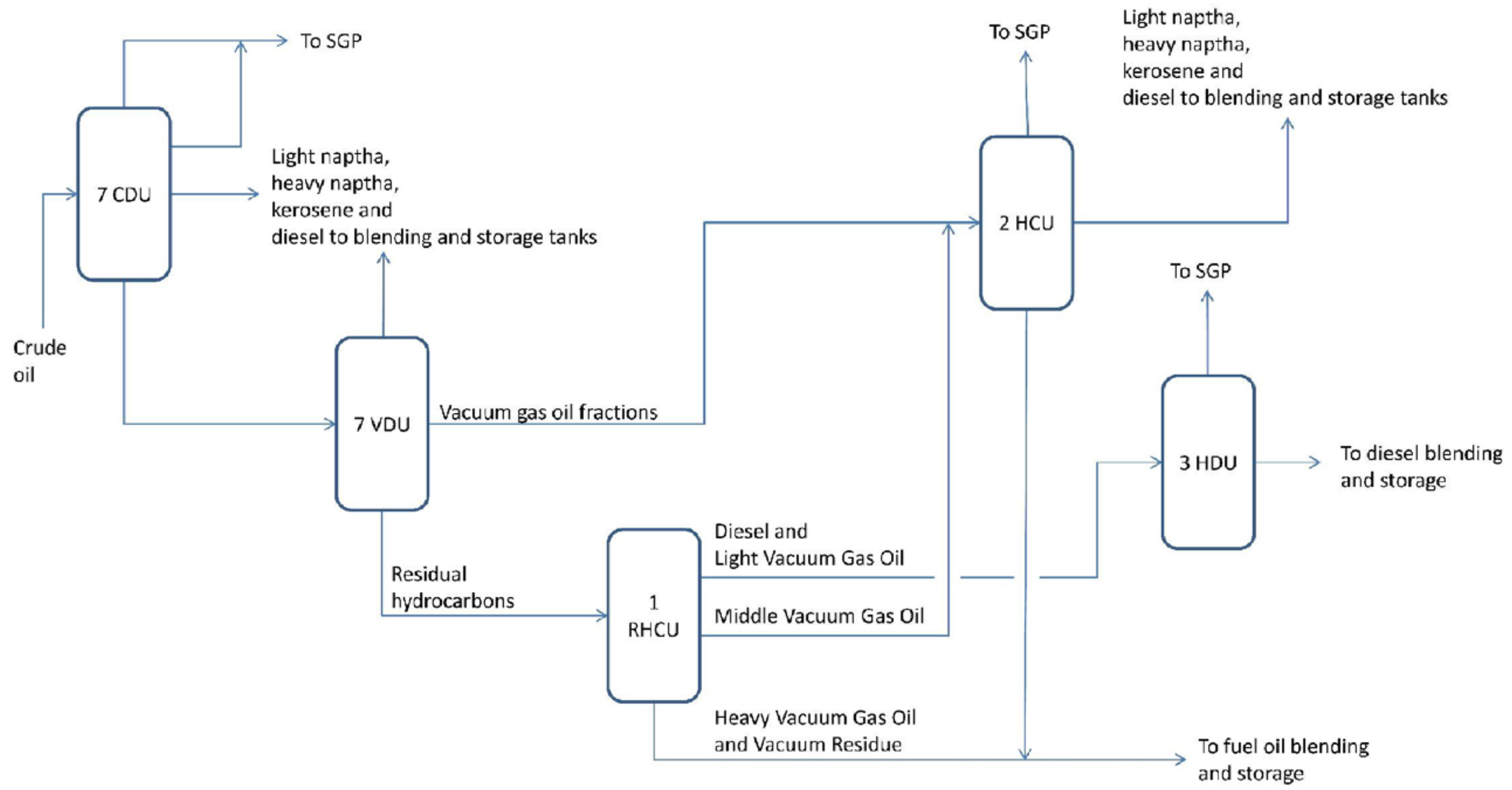
The BMP will require the provision of a new sub-station that will be located on land to the immediate south of the Refinery. The sub-station will be developed by the Electricity and Water Authority (EWA).

2.5.2 Water Use

The Bapco Refinery uses both seawater and groundwater. Seawater is used for cooling and is also desalinated for use as process water. Due to efficiency improvements, following implementation of the BMP, the quantity of water used will be approximately the same as the current Refinery.

Freshwater (desalinated water) is used for the following purposes within the Refinery:

1) Boiler feedwater (BFW).
2) Desalting crude oil.
3) Sour Water Stripping.
4) Closed loop cooling systems.



Key:
CDU - Crude Distillation Unit
VDU - Vacuum Distillation Unit
RHCU - Resideu Hydrocracking Unit
HDU - Hydro-Desulphurization Unit
HCU - Hydro-Cracking Unit
SGP - Saturated Gas Plant

Title: **Simplified Process Diagram**	
Project: Bapco Modernization Program	
Date: June 2016	Figure No. 2.3
Client: Bapco Technip	
Consultant: Environment Arabia	

CN:\Bapco Modernisation Plan\mxd\Process diagram1.mxd

Environment Arabia

2.5.2.1 Groundwater Use

Groundwater is abstracted from aquifer C within the Rus-Umm Er Radhuma (UER) limestone beds approximately 150 m below ground level (bgl). The Refinery uses approximately 1000 USgpm (5,450m^3/day) which is supplied to the firewater system and existing cooling towers. Following the BMP, groundwater consumption will be unchanged. The BMP units will not use groundwater.

2.5.2.2 Seawater Use

The Refinery uses seawater for cooling and also for desalination. Desalinated seawater is used as process water and boiler feedwater. Due to efficiency improvements, following implementation of the BMP, the quantity of water used will be approximately the same as the current Refinery.

Presently the Refinery operates multi-stage flash (MSF) distillation process units (#1, #2, #3) and multi-effect distillation (MED) process units (#4 and #5). As part of the BMP all of these units will be decommissioned and replaced with three new MED units.

The cooling water intake and effluent discharge points are shown on **Figure 2.4**. Seawater is taken from Farasiyah Bay from an intake located on a spit of land. Water is pumped from the Low Lift Pump House (LLPH) into open, cooling water intake flumes that are almost 2 km in length. At the end of the flumes the water passes through screens to remove detritus. Wash water from screening is directed to Seaweed Channel which flows into a lagoon. Once screened, seawater is pumped from the High Lift Pump House (HLPH) and distributed around the Refinery.

Once used for cooling, water is returned from various parts of the Refinery for discharge to sea either through the main outfall flume or through a discharge point downstream of #6 Oily Water Separator (OWS) – see **Figure 2.4**.

Estimates of seawater intake rates before and after the BMP are shown in **Table 2.2**. The maximum abstraction rate pre-BMP of 1,004,074m^3/day is defined by the capacity limitation of the pumps in the LLPH. These pumps will remain post-BMP and will continue to represent the absolute maximum intake rate. Although the capacity of the Refinery will be increased post-BMP, the amount of seawater used will be reduced. This is because the BMP will include an indirect, closed-loop cooling water system with cooling towers rather than a single pass cooling system.

Table 2.2 Seawater Abstraction Rates

Scenario	Normal		Maximum	
	m^3/d	US gpm	m3/d	US gpm
Pre-BMP	752,232	138,000	1,004,074	184,200
Post-BMP	716,132	131,377	915,179	167,893

Title: **Water Intakes and Effluent Discharge Points**

Project: Bapco Modernization Program

Date: March 2016

Figure No. 2.4

Client: Bapco Technip

Consultant: Environment Arabia

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2.5.3 Effluent Discharges

The existing Refinery discharges are as follows: cooling water; process wastewater; site drainage and domestic type effluent (from offices). All effluents are processed and routed to two discharge points into Farasiyah Bay – the Main Outfall flume and the discharge downstream from #6OWS. These are both shown in **Figure 2.4**.

Although the capacity of the Refinery will be increased post-BMP, the amount of seawater used will be reduced. This is because the BMP will include an indirect, closed-loop cooling water system with cooling towers rather than a single pass cooling system.

Figures 2.5 and **2.6** show the effluent steams both pre- and post-BMP for both discharge points. **Figures 2.5** and **2.6** include the discharge from Ma'ameer STP which discharges into the Main Outfall flume but this plant is not part of the Refinery and is not operated by Bapco. It treats domestic-type wastewater from Ma'ameer village.

Process effluents and drainage water that may contain oil or other contaminants are first routed to API Oily Water Separators, then to Induced Air Flotation (IAF) units and then to a Waste Water Treatment Plant (WWTP). The WWTP provides secondary treatment to reduce the organic loading and nitrogen content, and remove the dissolved contaminants from process effluents before discharge to sea via the Main Outfall.

Cooling water is returned to the sea at a higher temperature than the ambient water and may also contain residual biocide.

Domestic-type wastewater from the Refinery offices, canteen and bathrooms is routed to an on-site sewage treatment plant (STP) operated by Bapco, for treatment to reduce its organic load before discharge.

Reject water from desalination will be increased in temperature compared to ambient and will also be slightly more saline than ambient seawater. The implementation of the BMP will significantly increase the Refinery demand for desalinated water due to an increase of steam generation (mainly due to the new hydrogen production units). Also additional desalinated water will be required to be used as make-up for the new closed-loop, indirect cooling water system.

The BMP will create a new effluent comprising polishing regeneration effluent. This is a neutralised backwash effluent from an ion-exchange plant that will be used to polish desalinated water for use as boiler feedwater. This will be discharged directly to the Main Outfall.

In summary, the BMP will introduce several new effluent streams whilst retiring several existing ones. Overall, the BMP is not expected to significantly change the composition, temperature or volume of the effluents.

Figure 2.5 Discharges to Main Outfall Flume

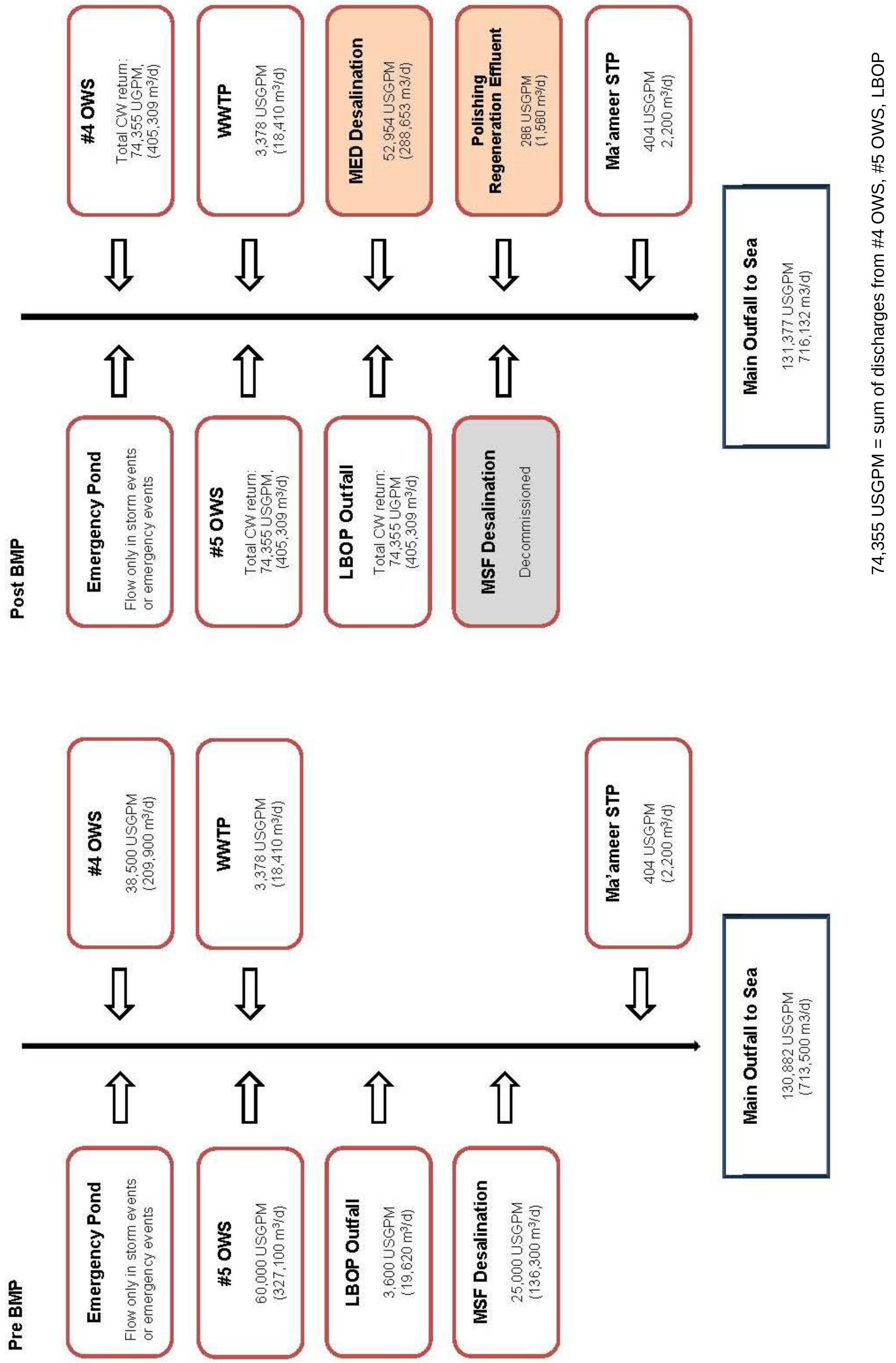
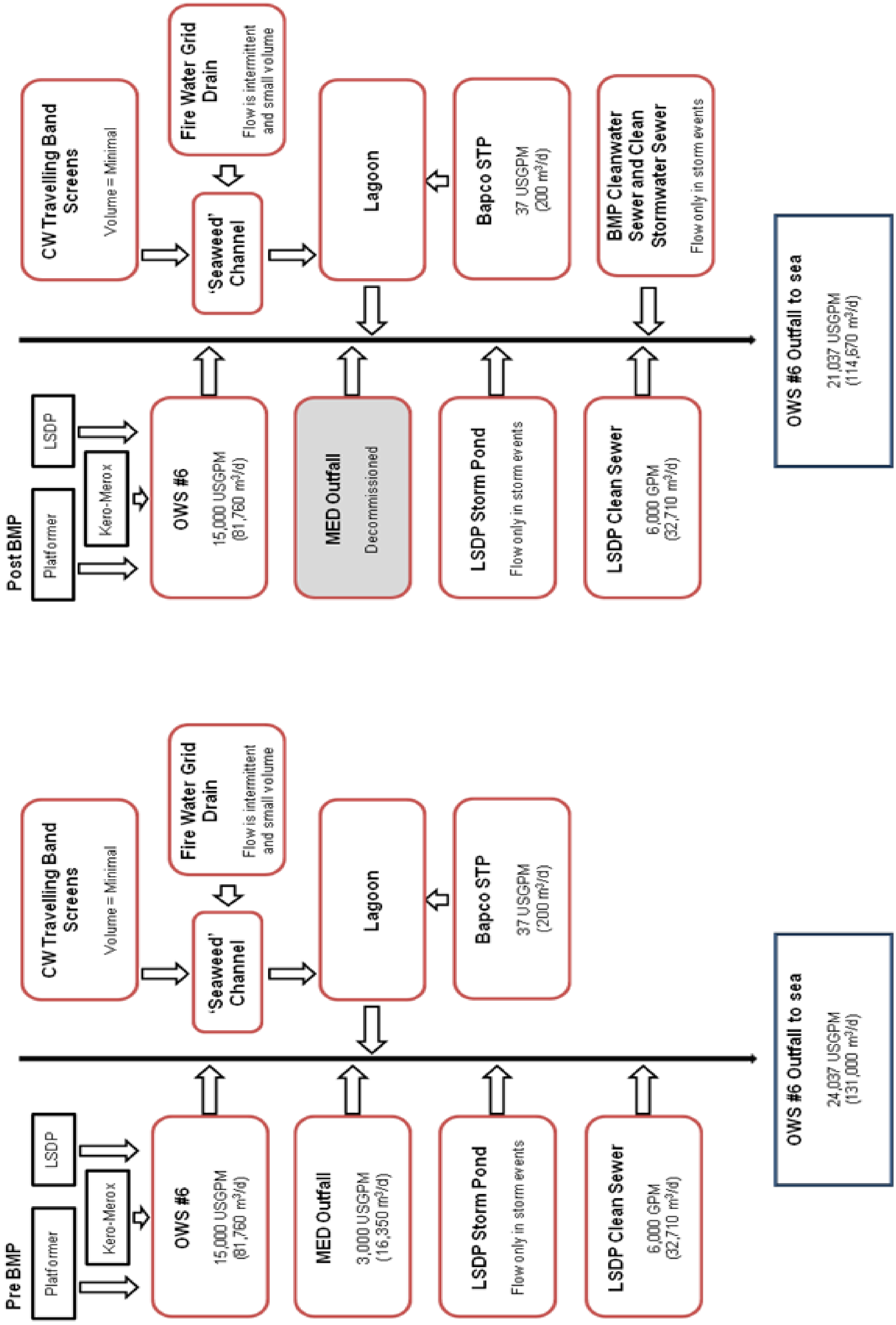


Figure 2.6 Discharges to #6OWS Pre- and Post-BMP



2.5.4 Sewers

Within the Refinery process wastewater and drainage water feeds via an oily water sewer or contaminated stormwater sewer into API oily water separators which then pass through the IAF units and finally to the WWTP before discharge to the Main Outfall flume.

The sewer system also includes an Emergency Pond which allows for the diversion of sewer water into a storage pond in the case of an oil spill or fire where a large quantity of water is used to dowse a fire and this enters the sewer system.

As part of the BMP additional sewers will be added:

1. Oily Water Sewer – will receive drainage water from BMP process plot areas where processes handle hydrocarbons. The system will also collect wastewater from other discharges that may contain hydrocarbon contamination such as desalter effluent water, steam generators blowdown, cooling tower blowdown in case of hydrocarbon contamination, crude tanks water draw-offs and oil drainages from skimmers. These effluents require treatment for removal of oil and will be treated using the existing WWTP.

2. Contaminated Stormwater Sewer (CSS) – will collect rainwater potentially contaminated by hydrocarbons from BMP process paved areas and tank bunds. The system is designed to hold the run-off from the first 30 minutes of rainfall where the run-off may be contaminated with hydrocarbons. After 30 minutes the drainage will be rerouted to the CSS. Any contaminated water will be collected in a surge basin, or within the pipe system capacity, and then pumped at a controlled rate to the existing WWTP. The surge basin may also be used to hold hydrocarbon releases and firewater during emergency situations.

3. Clean Water Sewer and Clean Stormwater Sewer – will receive BMP drainage from parking and office areas, roadways, walkways and building roofs. This water will comprise clean run-off and shall be discharged without treatment.

4. Sanitary Sewer – This will direct water from BMP bathrooms and kitchens to the Bapco STP (the Bapco STP was commissioned in 2014 and was designed with sufficient additional capacity to receive all sanitary sewer waste from the BMP).

2.5.5 Production and Storage of Gases

A cryogenic separator for nitrogen production will be part of the BMP to provide both gaseous nitrogen (GAN) and liquid nitrogen (LIN) for existing and new process units.

The BMP will also include two new hydrogen generation units (3 & 4 H_2 plant) to supply hydrogen to catalytic processes within the BMP (these are part of the main BMP process units).

The BMP will be a net producer of propane and butane. These gases will be liquefied to form Liquefied Petroleum Gas (LPG) and stored on site at the Refinery before being regasified and transferred to Sitra Wharf where it will be reliquefied and stored in three new storage tanks as LPG for export.

2.6 Changes to Refinery Storage Tanks

Additional storage tanks will be required at the Refinery site for storage of crude oil and intermediate products. Two new tanks will be provided for the RHCU unit and two new tanks to store crude delivered to the Refinery via the new A/B pipeline. In addition, there will be a need for new pumps and a major rationalization of existing Refinery storage tanks including decommissioning and demolition of some storage tanks.

2.7 Changes to Transfer Lines

The existing Refinery-to-Sitra transfer lines will revised. The use of some of the existing lines will be changed and some additional lines will be added. In addition, the pipe bridge across Ma'ameer Channel will need to be upgraded. A new pipe bridge will be constructed to the immediate south of the existing unit and the old unit will be decommissioned and demolished. During construction of the new pipe bridge, temporary land platforms will need to be reclaimed within Ma'ameer Channel to facilitate construction. This will be a temporary reclamation measure and all fill material used will be removed from the Channel on completion of the new pipe bridge. Ma'ameer Channel is not navigable and neither the construction phase nor the operational phase will impact marine navigation rights.

2.8 Changes to Sitra Tank Farm

Some modifications to the existing Sitra Tank Farm facilities will be required as part of the BMP, in particular a new naphtha/kerosene storage tank will be required as well as new shipping pumps that are able to achieve higher loading rates. There will also need to be a change of service on some existing tanks. The approximate location of the new storage tank is shown on **Figure 2.1**. Also, as part of the BMP, facilities for the import, storage and blending of MTBE will be provided including a storage tank at Sitra Tank Farm and transfer line(s) from Sitra Wharf. It is proposed to repurpose existing tanks and transfer lines for MTBE import and storage rather than construct new ones.

2.9 Changes to Sitra Wharf

2.9.1 Loading Facilities

Following implementation of the BMP, the increased rate of production at the Refinery will lead to an increase in the shipping rate for export of products. The export facilities at Sitra Wharf will be updated to cope with this additional demand and to replace old equipment with modern, efficient versions.

It is intended to keep the same wharf structures but to:

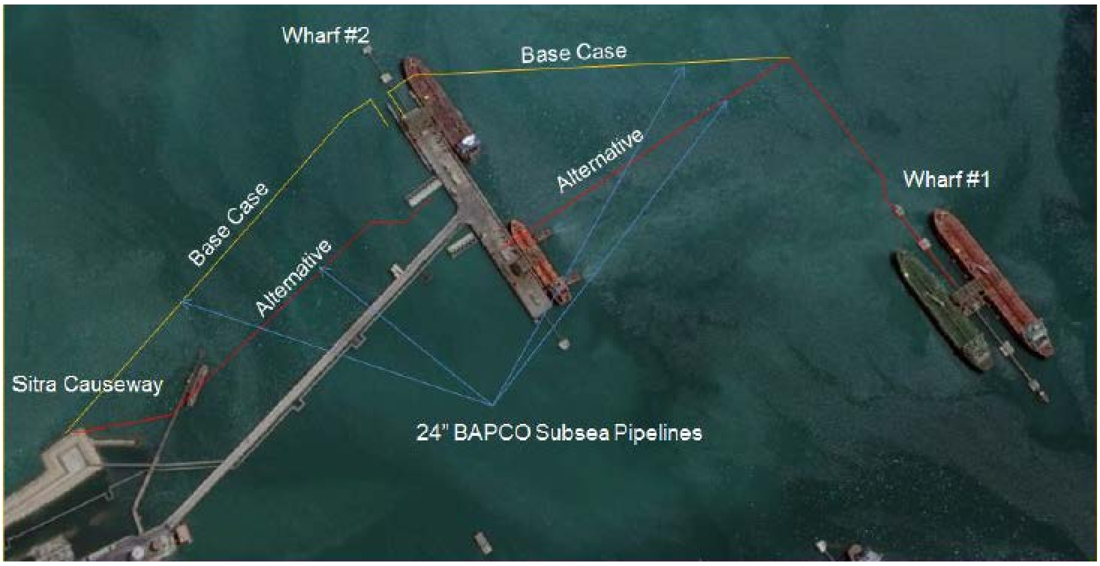
- add 19 new loading arms;
- add new slop facilities; and
- add new sealines and change the service on some existing sealines.

New loading arms will be added to replace existing loading hoses. New slop facilities will be required to drain the loading arms following loading of vessels. The arms will drain into slop tanks which will pump slops back to a slop tank at Sitra Tank Farm which in turn will pump the slops back to the Refinery for reprocessing.

Three 24”, sealines will be added for the transfer of middle distillate products and 16” and 10” lines will be added for the transfer of LPG and the return of LPG vapour, respectively. The proposed preferred and alternative locations of these sealines is shown in **Figure 2.7**, note two route options are presented, the base case with a route of 930 m, and an alternative of 740 m. The base case is recommended by COWI (2016)[2] due to advantages in installation, interfaces with existing systems and safety criteria.

Following implementation of the BMP, the following sealines will be decommissioned: 4” LPG, #s 1, 2, 3, 4, 7, 10, 11, 12 sealines, naphtha jet fuel and caustic transfer line.

Figure 2.7 Proposed Location of New Sealines at Sitra Wharf



Pipeline strings, and pipe stalk lengths, will be pre-fabricated on reclaimed land (part of the already permitted NOGA Terminal Platform) prior to being pulled to site with the aid of buoyancy modules and a shallow draft vessels. Operations will require work vessels to operate within the areas adjacent to Berths 1-3 at Wharf #2. The following main steps will be performed during pipeline installation:

- Tow/ transport pipe strings to offshore locations;
- Release of the buoyancy tanks using divers;
- Lowering the pipe string to the position;
- Bolt up the end flanges.
- Backfilling to a depth of 1 m above pipeline; and
- Installation of pre-cast mattresses with rock cover at Wharf #1 approach.

Construction of the new sealines will have short-term impacts on the operation of Sitra Wharf. Additional navigational controls will be needed within and around the Wharf to ensure that the construction work and day to day wharf activities can be carried out together.

[2] COWI (January 2016) BAPCO Modernization Program. Subsea Pipeline Routing Feasibility and FEED.

2.9.2 LPG Storage

Three new LPG refrigerated tanks will be installed on land to the north of the wharf to be reclaimed by NOGA.

2.10 AGAS Facility

AGAS operate a facility in the western part of the Pitch Ponds site. The facility was set up as a commercial venture with Bapco, the land owner, to recover and recycle liquid pitch. The AGAS facility recovers and processes the pitch to clean it so that it can be used as an additive in oils. Almost all of the liquid pitch has been recovered, only the area immediately adjacent the AGAS facility contains liquid pitch which is stored in open ponds approximately 2m deep. The extent of the AGAS plant and remaining Pitch Ponds are shown in **Figure 2.8**.

AGAS are continuing to recover the remaining pitch until completion and then the facility will be decommissioned and demolished from the site. This work will be undertaken by AGAS and is not part of the BMP. When the land is returned to Bapco it will be used as a construction laydown area and temporary construction facility during construction phase of the BMP, and it will be in similar condition to the remainder of the Pitch Ponds site.

2.11 Construction

2.11.1 BMP Construction Schedule

Presently it is expected that construction will commence in 2017 and the BMP will be fully commissioned and operational in 2021.

2.11.2 Site Preparation and Changes in Site Levels

To facilitate the BMP construction there will be a requirement to change the levels of parts of the site. This will provide an even surface for construction and provide suitable drainage gradients to allow gravity drainage in sewers and pipes. In particular the Pitch Ponds comprise a low lying area with an average elevation of around 2 m AOD. It is expected that it will be necessary to raise this area of the site to around 5 m AOD. This will require that approximately 1,500,000 m^3 of suitable fill material is brought to site to create a development platform. In other areas of the BMP there will also be a requirement to undertake cutting and filling to level areas of the site but not to the extent required in the Pitch Ponds area. **Figure 2.9** shows cross-sections of the Refinery and Pitch Ponds sites which show preliminary designs for the cutting and filling work to profile the site to the desired levels.

Title: **Location of AGAS Facility and Remaining Pitch Ponds**			Client: Bapco, Technip
Project: Bapco Modernization Program			
Date: March 2016	Figure No.: 2.8		Consultant: Environment Arabia
Datum: WGS 84 - UTM 39N	Scale: 1:10,000 (A4)		

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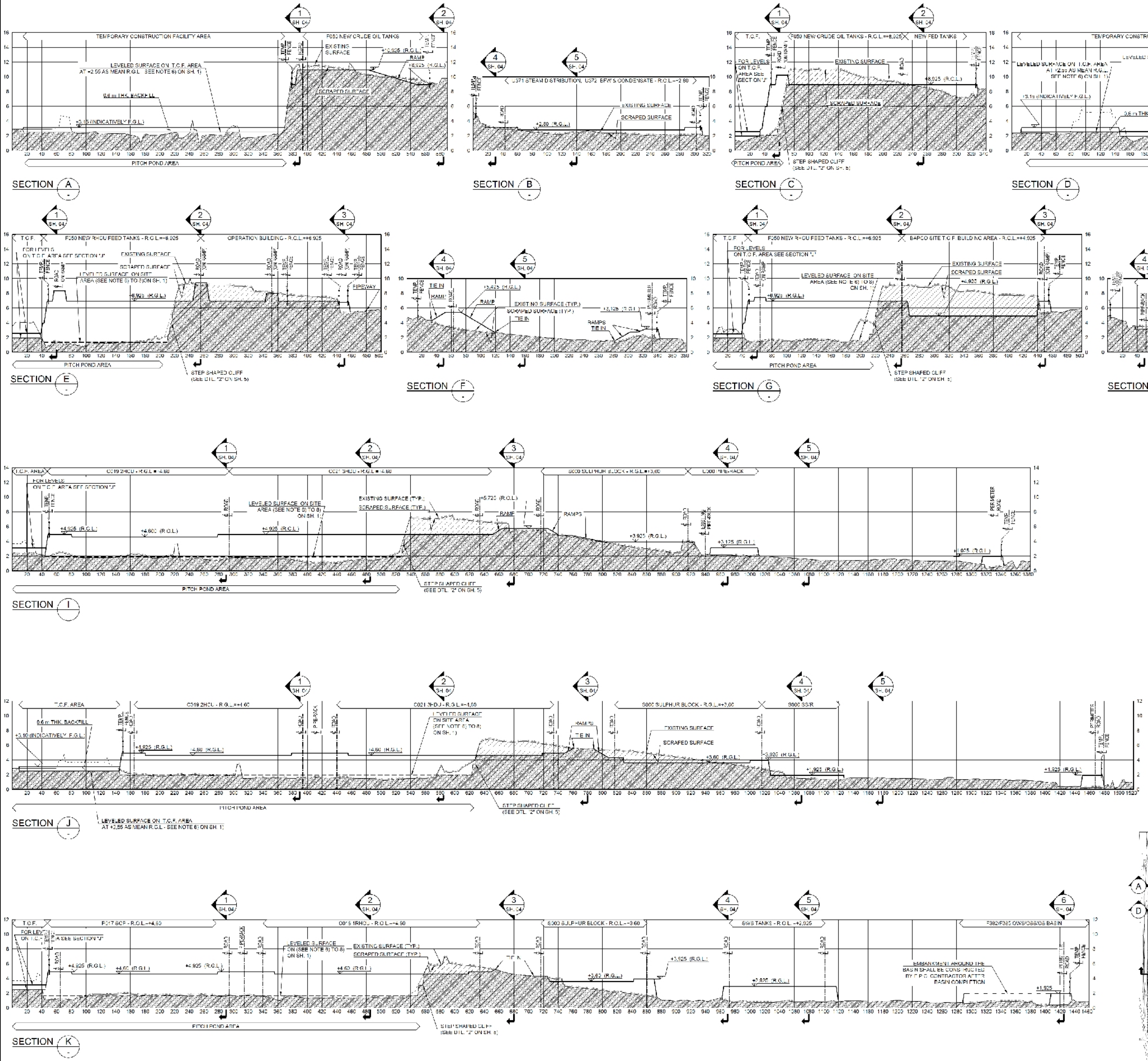
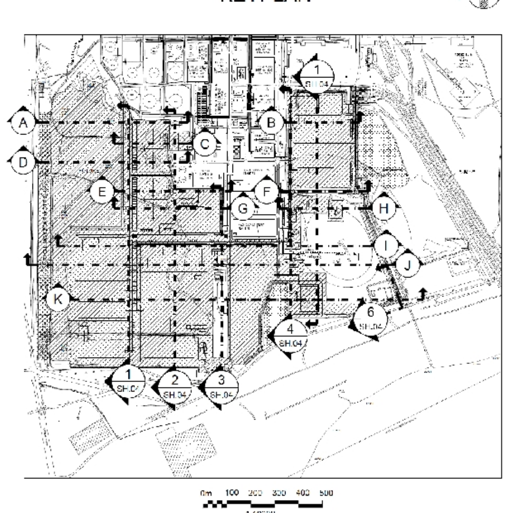


LEGEND

	EXCAVATION
	FILL
	UNDISTURBED SOIL
R.G.L.:	ROUGH GRADE LEVEL

KEYPLAN



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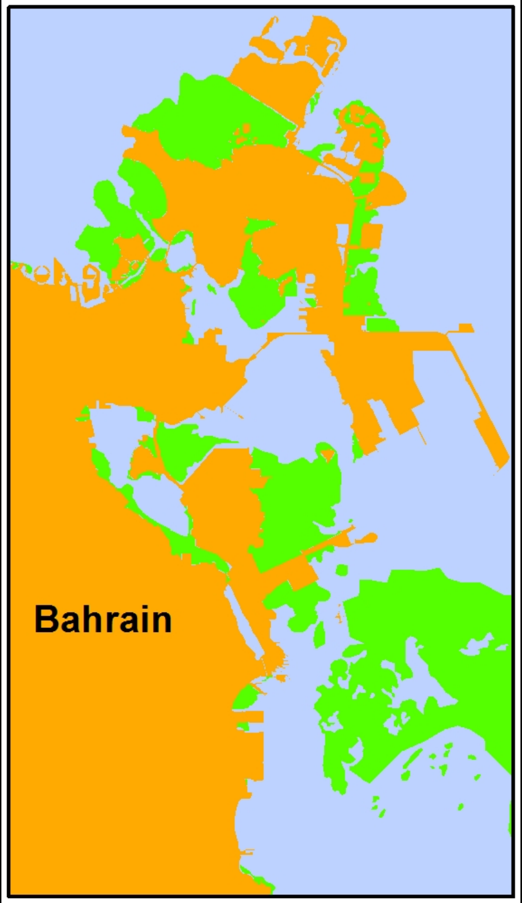

Title: **Cross-sections Showing PreliminaryDesigns for Cutting and Filling**

Project: Bapco Modernization Program

Date: June 2016

Figure No. 2.9

Client: Bapco Technip

Consultant: Environment Arabia

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2.11.3 BMP Plant Construction

Once the main BMP site has been in-filled, levelled and prepared, construction can commence. This will comprise the following main activities:

- Mobilisation;
- Site preparation;
- Excavation;
- Piling;
- Foundations;
- Mechanical and piping erection;
- Electrical installation; and
- Thermal insulation.

The BMP construction will be divided into three work packages (WP), namely 1, 2 and 3. Each package would have its own dedicated laydown area, camp area and office area as shown on **Figure 2.6**. There will also be an area for client offices.

2.11.3.1 Labour Camps, Construction Laydown Areas and Construction Site Offices

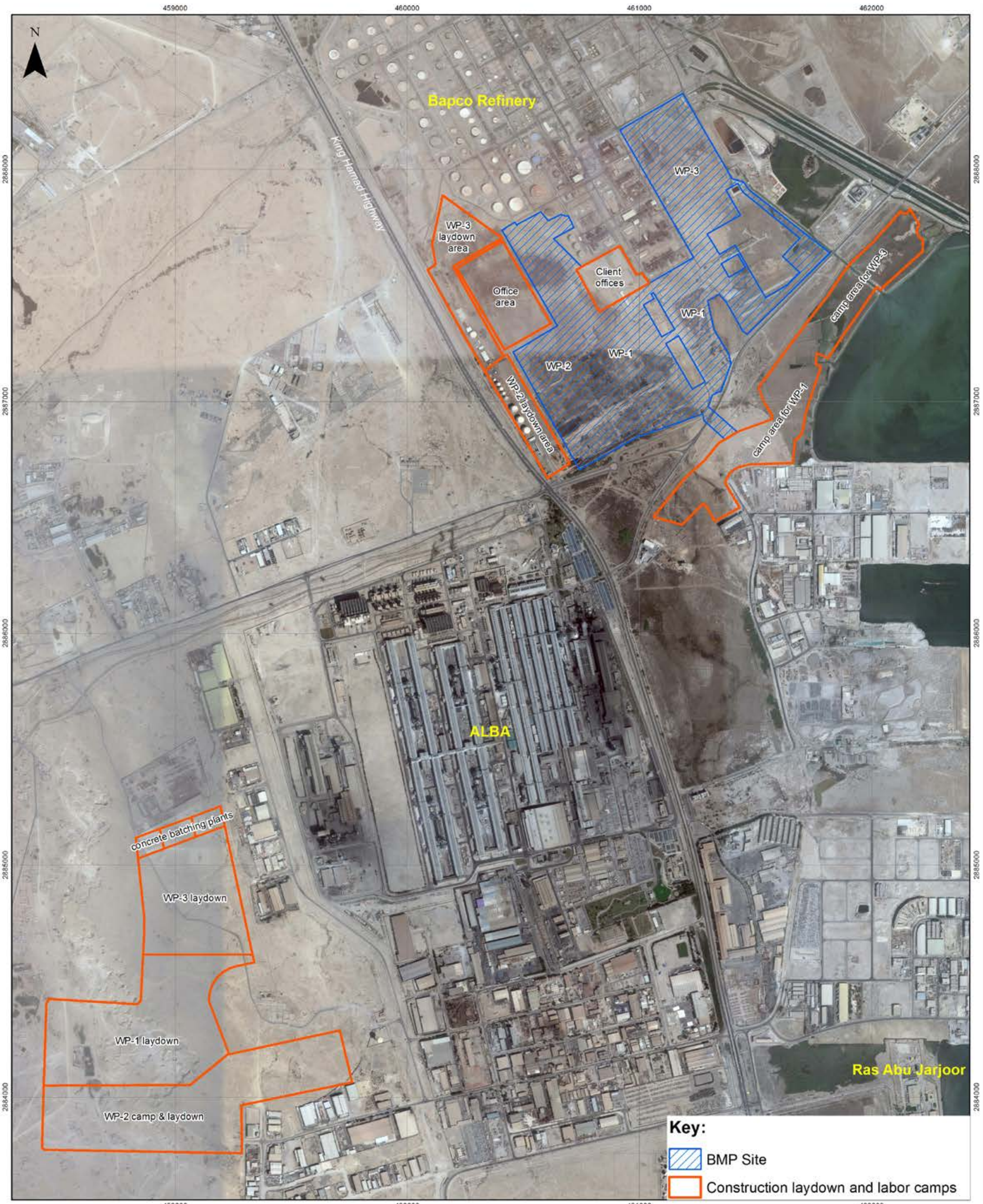
To facilitate the construction of the BMP there will be a requirement for laydown areas to store construction materials and elements of new process plant prior to assembly, for construction site offices and labour camps to house a large number of construction workers. **Figure 2.10** shows the areas that have been proposed for these uses during construction.

Within the Pitch Ponds site, there would be construction laydown areas for WP-2 and WP-3 and site offices. To the south of the Pitch Ponds site on the coastline, there would be camp areas for WP-1 and WP-3. Off-site, to the west of the Alba facility, laydown areas have been earmarked for WP-1 and WP-2. The labour camp for WP-2 would also be located in this area, as would a separate concrete batching plant for each work package (three plants).

The labour camps would include: sleeping accommodation, canteens, recreational spaces and facilities, sanitary facilities and laundry facilities. The labour camps will be designed to be safe, comfortable and practical and to provide on-site recreation for workers. The labour camps will be sized to accommodate a peak of 15,000 construction workers.

The labour camps and construction site offices would be serviced with mains electricity and mains supplied potable water. Sewage from labour camps for WP-1 and WP-3 will be treated in package STPs and the treated effluent will be discharge to sea under the conditions of a discharge permit. For the labour camp associated with WP-2 to the west of Alba, sewage will be discharged to sewer under the terms of a discharge agreement with the sewage undertaker. In the case of the construction site offices, sewage will be discharged into septic tanks which will be periodically emptied and the waste water will be tankered away and treated at a municipal STP.

On completion of the BMP construction and commissioning, the laydown areas and labour camps will be decommissioned and removed or demolished.



Title: **Location of Construction Laydown Areas and Labour Camps**		Client: Bapco Technip
Project: Bapco Modernization Program		
Date: March 2015	Figure No.: 2.10	Consultant: Environment Arabia
Datum: WGS 84 - UTM 39N	Scale: 1:15,000 (A4)	

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2.11.3.2 Transportation of Personnel and Materials

The BMP construction will require the transportation of millions of tonnes of fill, steelwork and other building material and equipment to site. It will also require the workforce to be transported to and from site each day.

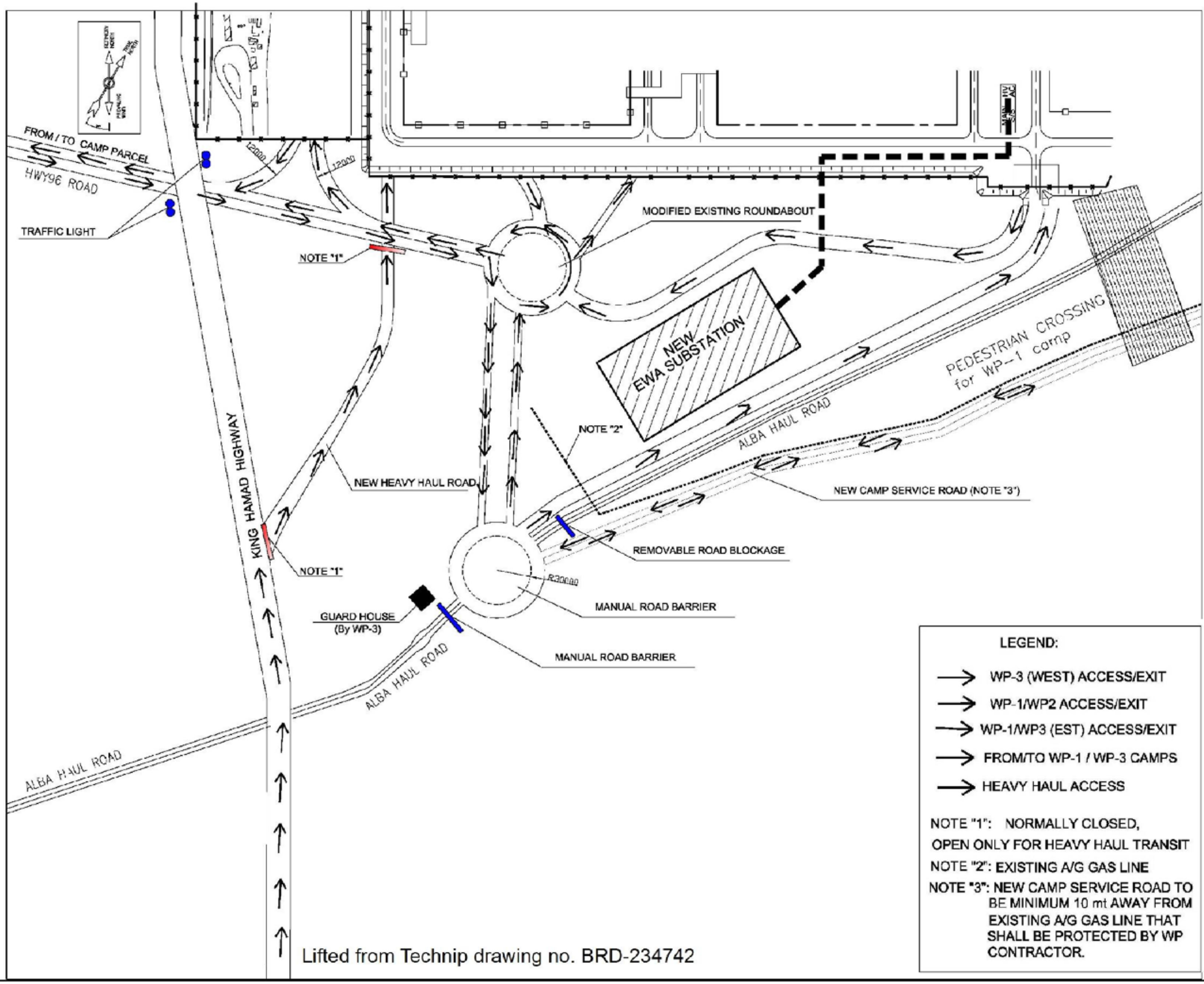
The BMP site will be accessed from King Hamad Highway to the west of the site which is a dual carriageway. As part of construction mobilisation, junction improvements will be made to facilitate site access, **Figure 2.11** shows a preliminary design for the access improvement.

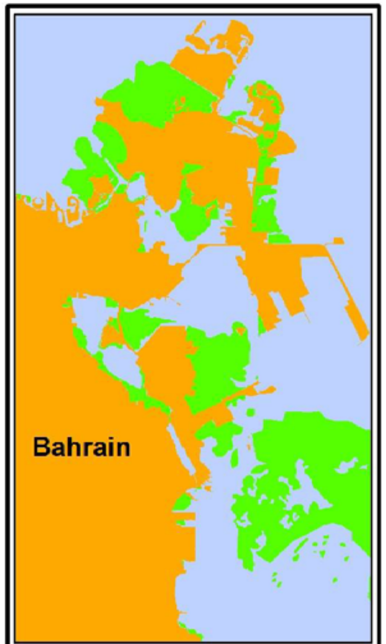
The source(s) of the fill material for the infill and site preparation has not yet been selected. Contractors bidding for the work have been instructed that they will be able to use multiple sources of fill in order to facilitate transportation of the material to site. The majority of construction materials for the BMP plant will be imported to Bahrain through Khalifa Bin Salman Port, which is the main commercial port of Bahrain.

Constructability studies have identified oversized loads that will require careful planning to achieve safe delivery to the site. The main oversized loads expected are listed in **Table 2.3** below. It is expected that these will be brought to site using a jetty in the industrial area to the immediate south of the Bapco Refinery. They would then be transported the short distance to the Refinery using existing roads or a temporary haul road. Transport of oversized loads may require temporary works to road structures such as traffic lights and overhead electrical cables to create sufficient clearance.

Table 2.3 Main Expected Oversized Loads for BMP Construction

Item	Quantity	Length (m)	Width (m)	Height (m)	Weight (tonne)
Atmospheric Column VPII	1	60	11	11	615
Vacuum Column VPII	1	54	11.5	11.7	450
1st Train Reactor VPI	2	53	5	5	1,050
2nd Train Reactor VPI	2	53	5	5	1,000
1st Stage Reactor VPII	1	45	5.6	5.6	1,250
2nd Stage Reactor VPII	1	36	4.6	4.6	570
Product Fractionator VPII	1	66	7.35	7.35	330
Product Fractionator VPII	1	55	6	6	180
C3 Storage Bullet	1	60	7	10	380
C3 Storage Bullet	1	60	7	10	380
C4 Storage Bullet	1	60	7	10	290
C4 Storage Bullet	1	60	7	10	290
Off-Spec / Spare LPG Storage Bullets	1	60	7	10	380
Off-Spec / Spare LPG Storage Bullets	1	60	7	10	380





Title:
Preliminary Design for BMP Access

Project:
Bapco Modernization Program

Date:	Figure No.
June 2016	2.11

Client:
Bapco Technip

Consultant:
Environment Arabia

CN:\Bapco Modernisation Plan\mxd\BMP Access prelim design.mxd

As the labour accommodation for WP-1 and WP-3 will be located immediately to the south of the BMP site, only short sections of private road will be required to transport workers to the BMP construction site from the labour accommodation. However, the labour camp for WP-2 will be located to the west of Alba and this will require the co-ordinated movement of 4000-5000 workers per shift to and from the BMP construction site.

2.12 Commissioning

During commissioning new BMP units will need to be cleaned, inspected, electrically tested, pressure tested, and then tested in operational mode until they can be operated to the manufacturers' specifications. The units will then be handed over to Bapco for operation and production. Once the units are stably operating and have been handed over, any superseded units in the Refinery will be shutdown, decommissioned and demolished.

2.13 Decommissioning and Demolition

2.13.1 Plant Requiring Decommissioning and Demolition

Shutdown, decommissioning and demolition of redundant plant can be commenced once the new BMP units have been started up and are running stably. After BMP implementation, several types of facilities will not be used anymore comprising:

- Complete process units;
- Storage tanks;
- Cooling water towers;
- Buildings; and
- Interconnecting piping.

Tables 2.3 and **2.4** show the process units and infrastructure that will be replaced by the BMP. In addition a number of storage tanks within the Refinery tank farm will be decommissioned. The list of tanks to be decommissioned is still to be finalized but a provisional list is shown in **Table 2.5**.

Table 2.4 Process Units to be Decommissioned and Demolished

Plant #	Plant Name
1	1 Crude Unit
1	2 Crude Unit
2	1 VDU
3	CGRU
4	3 Crude Unit
5	1 LPG
6	FCCU
8	2 Poly
15	GTU
32	5 VDU
52	Asphalt Plant
55	RHLF
87	1 HDU
89	1 VBU

Plant #	Plant Name
90	90C2 (C2 Rerun)
91	GCU

Table 2.5 Provisional List of Refinery Storage Tanks to be Decommissioned and Demolished (including piping and instrumentation)

#	Tank tag	Service
1	50D261	Leaded Slop
2	50D262	Leaded Slop
3	50D264	Gasoline
4	50D265	Gasoline
5	50D356	Straight Run Naphtha
6	50D360	Diesel Rundown
7	50D363	Diesel Rundown
8	50D369	Slop
9	50D452	Diesel Rundown
10	50D455	Diesel Rundown
11	50D460	Straight Run Naphtha
12	50D461	Diesel Rundown
13	50D465	Diesel Rundown
14	50D466	Leaded Slop
15	50D467	Leaded Slop
16	50D469	Gasoline
17	50D470	Gasoline
18	50D475	Gasoline
19	50D476	Gasoline

Table 2.6 Ancillary Plant to be Decommissioned and Demolished

#	Tag	Service
1	1CTW101	1&2 CDU Cooling Tower
2	89CTW8901	1 KRU/VBU Cooling Tower
3	#1,2,3,4,5 Desal	Desalination plant

Table 2.7 Infrastructure to be Decommissioned and Demolished

#	Facility Identification
1	Existing Boiler shop
2	I&E Building
3	Wet Gap Piping

2.13.2 Decommissioning

Following shutdown the plant units to be demolished will be physically and electrically isolated from the remaining plant. Once isolated each unit will be decommissioned. This process will involve the following range of activities:

- Removal of residual feedstock, process materials and products in pipelines, piping and equipment, vessels, tanks, drains;
- Removal of catalyst materials in process vessels;
- Removal of residual chemical stocks in treatment systems;
- Removal of residual fuels (oil, hydrocarbon, etc.);

- Removal of acid and caustics; flushing and cleaning of storage tanks;
- Cleaning of internal equipment, filters and holding tanks;
- Removal of hazardous waste and combustible materials; and
- Disconnection in relevant rackroom of control systems.

2.13.3 Demolition

Prior to demolition of each process unit or tank, a demolition plan will be prepared that will include a structural survey of the item of plant. The survey will identify the appropriate method and sequence of demolition so that the structure remains safe throughout the demolition process.

It is intended that all redundant above ground plant and structures will be removed. Foundations, paving and hardstanding will be removed to 300 mm below ground level. The ground will be left at its existing level and covered with sand or clean, crushed fill from the demolition work. The ends of any remaining underground pipes will be capped with cement and fill material.

No equipment, electrical and instrumentation is to be reused or recycled, all materials are to be scrapped.

2.13.3.1 Health and Safety

Health and safety requirements that will apply to the whole project including decommissioning and demolition are described in **Section 21**.

2.13.3.2 Hazardous Substances and Waste

Decommissioning has the potential to give rise to a number of hazardous waste streams. These include asbestos containing materials (ACM), lead contaminated materials and sludges and hydrocarbon contaminated sludges. No electrical equipment at Bapco contains PCBs and consequently there will be no wastes of this type. Proposals for management of wastes from decommissioning and demolition are described and assessed in **Section 16**.

3 LANDUSE AND PLANNING

3.1 The Need for Planning

In simple terms, the objectives of land use planning include the prevention of land use conflict and ensuring the requirements of those using the land are met. An example of land use conflict is to place heavy, polluting industry near to a residential area, or vice versa. An example of requirement provision is to ensure adequate schooling or facilities for dealing with waste water provision are in place in an area identified for residential development. The consideration of existing land use and planning policies within ESIA is important to facilitate the assessment of impacts.

3.2 Bahrain 2030: The National Plan

A National Plan (MoMA, 2007) has been produced for Bahrain with the goal to "*assure Bahrain's evolution and expansion through the thoughtful twining of land use and economic growth"*. The National Plan is intended to guide growth in an organised and sequential way, creating an *"intelligent island"* that is the financial, business and banking capital of the Gulf Region. The National Plan is based on the delivery of ten key strategies:

- **01 One Plan:** the concept that a focused, centralised and predictable vision is required with all future development conforming to this one National Plan.
- **02 Market Economy:** realising the potential for economic growth, increased productivity and higher profit employment, in finance, tourism, niche manufacturing, education and health care. The National Plan identifies places for innovation, including Sitra Technology City and Muharraq new industry campuses.
- **03 Environmental Resources:** encouraging all economic growth to take place in ways that enable the Kingdom's terrestrial and marine environments to be safeguarded and restored. This includes balancing new development with protected areas.
- **04 Transportation:** delivery of a multimodal transport network providing safe, efficient and convenient access. This includes strategic routes, between Khalifa Bin Salman Port and the Saudi Arabia Causeway for example, for rapid international transportation of goods.
- **05 Distinct Communities:** creating safe, vibrant places to live and work to meet the housing needs of the broadest range of Bahrainis. This includes protecting and enhancing historic districts by renovating and conserving their historic buildings and spaces.
- **06 Public Waterfront:** the National Plan calls for a continuous waterfront from Budaiya to Juffair as part of a dramatic increase in publicly accessible waterfronts throughout the Kingdom.
- **07 Protection of Cultural and Archaeological Heritage:** recognition of the value of Bahrain's national heritage through increased public awareness and enhanced public education.
- **08 Military Needs:** to consolidate land use by the military, developing a new campus *at Sheikh Isa Air Base* and considering the return of under-utilised land to civilian use. This may include for conservation or tourism purposes, for example at Hawar Islands.

- **09 Green the Country:** to restore the tradition of Bahrain being the *'land of a million palms"*, including the enrichment of existing and new urban areas with parks, plazas and streetscape.
- **10 Sustainable Future:** to introduce sustainability as a common theme within all national policies. Integrated resources management is to be considered for Bahrain's natural resources, including sand, water, oil, gas and treated sewage effluent.

3.2.1 Study Area Plan

During a meeting held with the Ministry of Works, Roads Directorate on 6th October 2015, EACS received a Development Plan for East Sitra Islands, issued by the General Directorate of Urban Planning on 6th June 2012. The Plan is provided in **Appendix 3A** and shows a future road passing to the south of the Pitch Ponds which is part of the East Sitra Link Road – a future planned strategic road link connecting Um Al Hassam Interchange to Nuwaidrat roundabout. The Plan also shows large reclamation plots to the south and north of Sitra Wharf. The Roads Directorate has indicated that the East Sitra Link Road is at the feasibility stage and they have invited consultants to bid for studying the potential impact of the road on concerned stakeholders in the area.

The plot to the north of the Sitra Wharf is the East Sitra Housing Development for which the reclamation is almost complete. The Urban Planning Directorate has advised that the large reclamation plot to the south of the Wharf is a long-term development prospect.

The route of the future planned Bahrain-Qatar Causeway lies to the south of South Alba Industrial Estate. The landfall junction will be located approximately 4 km from the southern boundary of the Refinery.

NOGA is currently reclaiming land to the north of the existing GPIC complex to provide storage for petroleum products. There are also plans to expand GPIC, with the addition of a new ammonia plant, a granular urea plant and urea granulation unit, together with utilities and associated offsite facilities. This development is proposed to take place on existing reclaimed land adjacent to the existing GPIC complex. This project is not yet consented.

Banagas plan to increase their capacity for LPG export and as such are planning to build additional LGP storage tanks at Sitra Wharf. This project is not yet consented.

Furthermore, Alba (aluminium Bahrain) also plans to increase their capacity which may require some changes to the Wharf to increase its capacity to import alumina and other bulk raw materials. The expansion of Alba includes construction of a 6th new aluminium production line and additional gas-fired power generation capacity at their manufacturing facility located to the south west of the Bapco Refinery. The project received environmental permission from the SCE in 2015 (Alba, 2015).

3.2.2 National Plan Strategies Relevant to the Study Area

Enclosed within the second and third key strategies of Bahrain National Plan 2030 outlined above are sub-strategies in industrial development as well as in the marine and coastal areas respectively. These sub strategies are discussed in the following sections because of their relevance to the current project.

3.2.2.1 Industrial Strategy

Industrial development has always been regarded as an integral factor in maintaining a robust market economy. To implement Bahrain's vision of attaining a further upscaled economy by 2030, it has developed an Industrial Strategy[3] contained in the Bahrain 2030 National Plan. This scheme involves a concrete plan of action that proposes a full scale industrial development whilst at the same time planning to mitigate the impacts that may occur on other development aspects such as environment, tourism, property/residential developments, etc.

Thus, the industrial strategy has included a clear demarcation of areas known as industrial corridors (shown in **Figure 3.1**) not just to allocate adequate land for industrial development, but to effectively utilise these areas through investment in high quality, as opposed to hasty and haphazard, developments. This in one way could be manifested through the designation of industrial sites according to suitable type/category an industry belongs to (i.e. whether it is heavy industry, light industry or high-tech industry as seen in **Figure 3.1**). As suggested in the National Plan, the development will be carried out in phases giving priority to the establishment of heavy industries. Subsequent development of industries will flexibly adapt to the immediate economic needs and programme of the country.

3.2.2.2 Marine Environment Strategies

A strategy that would direct conservation and protection measures and ensure a sustainable exploitation within the coastal and marine environment has become imperative with the concurrent developments in the terrestrial area. For this reason, the National Plan has included proposals for the creation of a Marine Spatial Plan (MSP). The MSP according to the National Plan *"will provide a framework for the integrated management of human uses and assist decision-making across a wide range of cross cutting functions including: spatial allocation; advice on strategic ESIA's / SEA (Strategic Environmental Assessment) consenting processing; research into potential threats and impacts; and monitoring".*

Two frameworks within the MSP that serve to guide future planning and management in the marine area have been suggested in the National Plan and are relevant to the current study. These are Regional Coastal Cells and Marine Policy Zones.

Regional Coastal Cells (RCC) - is a scheme which proposes to partition or group the marine and coastal environment according to consistency in marine habitat, hydrodynamic influence, or specific physiographic features for the purpose of managing the same. The end goal is to divert destructive impacts away from sensitive areas. **Figure 3.2** shows the proposed five regional cells for Bahrain.

Within RCC 2 there are two outfalls belonging to the Refinery. Within RCC 2 the following issues should be considered:

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[3] Industrial Strategy: sub-strategy contained 02 Strategy – Achieve a Market Economy Specialized in Global and Regional Markets. NPDS, Bahrain 2030. The National Plan

- Wetland Area (Mangrove) Tubli Bay MPA and Ramsar Site;
- *Fasht Al Adhm;*
- Industrial Development Pressures;
- Industrial and Domestic Waste Water Discharge;
- Qatar-Bahrain Causeway Proposal;
- Intertidal Shrimping Grounds;
- Desalination Plants;
- Shipping Operating and Marine Risks; and
- Agricultural Runoff.

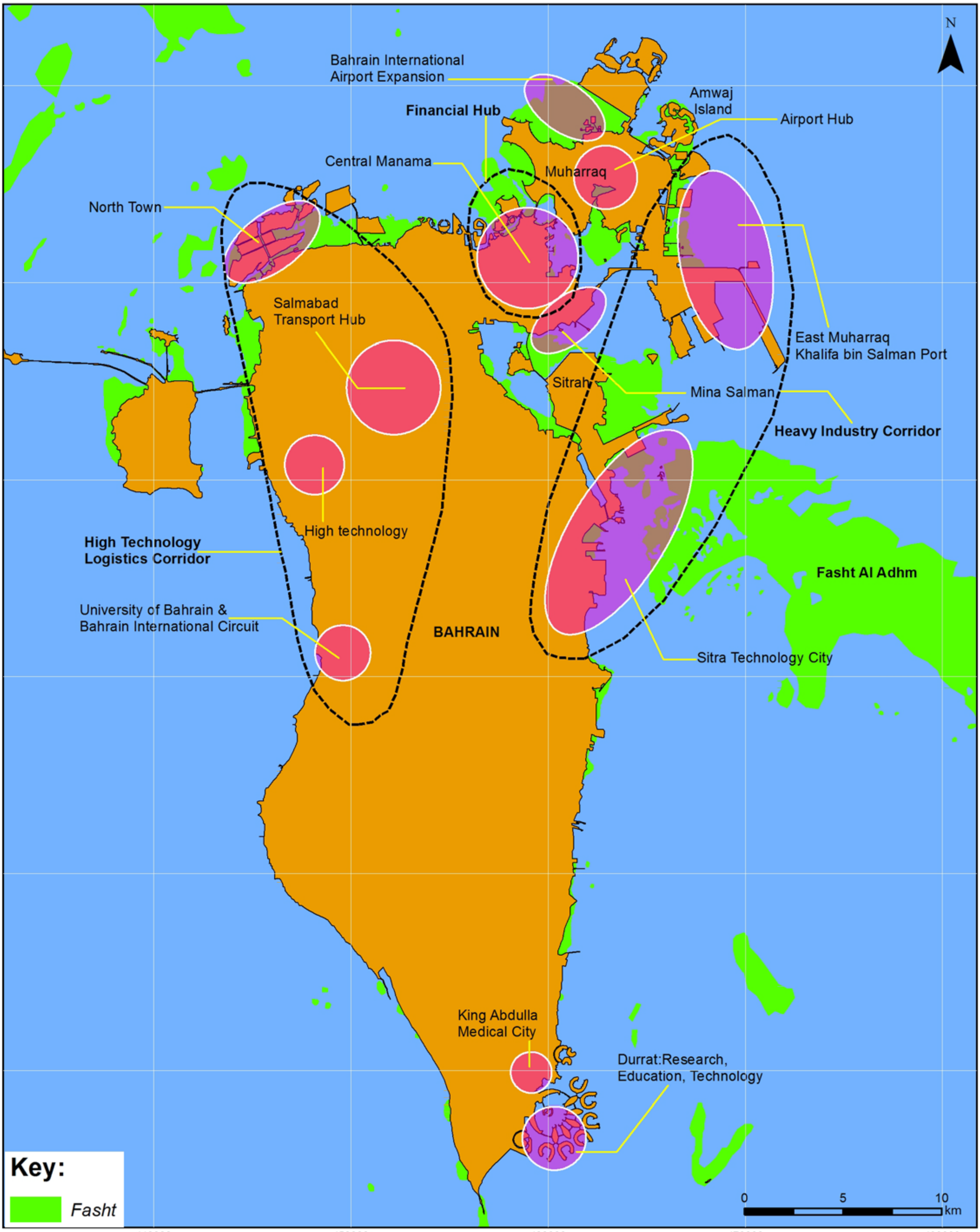
Although *Fasht Al Adhm* (because of its ecological and fisheries value) is the main issue, the overlapping interaction of human activities and its cumulative effects that are occurring and expected to occur (Qatar-Bahrain Causeway, future reclamations for industrial developments) in this area warranted RCC 2 to be suggested as the first Area Action Plan (AAP) for Bahrain. An APP according to the National Plan "requires further baseline data to be collated BEFORE any decision is taken on assigning future land and sea use within its boundary".

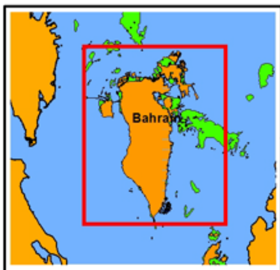
Marine Policy Zones – The National Plan has set out an integrated management of areas called Marine Policy Zones or MPZ's, within RCC's. MPZ boundaries are determined in terms of their respective environment and socio-economic value shown in **Figure 3.2**. The management criteria for each zone are described in **Table 3.1**.

Table 3.1 Management Zone Categories

Type of Zone	Management Criteria
General use	Would provide for reasonable uses
Development	Would be available for marine development
Habitat Protection	Would provide for reasonable use except for e.g. offshore dredging or commercial fishing
Conservation	Would allow reasonable recreation uses only
Buffer	Adjacent to above habitat protection and conservation zones to prevent sharp transition boundaries
Preservation	Total preservation, all entry prohibited except in emergency. This includes Marine Protected Areas
Special Management	Shipping, seasonal closure areas (e.g. nursery grounds) fisheries, experimental areas, technology experimental areas, defence areas

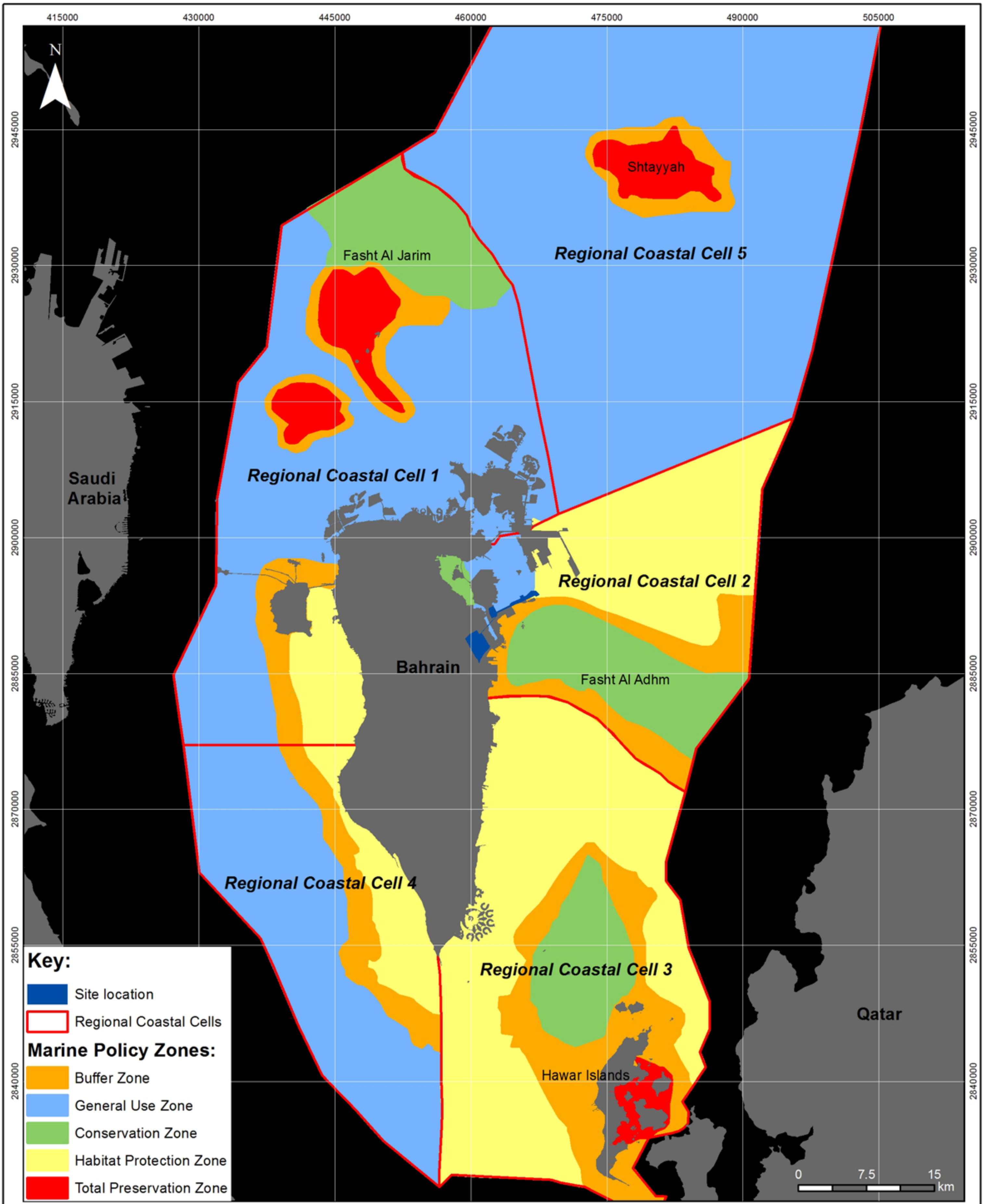
The south eastern boundary of the Refinery on the coastline is situated within a transition boundary or buffer zone to a known conservation area designated by the MPZ, F*asht al Adhm.* This is the main conservation area and lies about 2.8 km east. Within a 3 km radius from the existing Bapco discharge points, lies a portion of the conservation, buffer zone and preservation zone. The sea to the east of the industrial area is known for the country's best fishing and shrimping grounds (highlighted on **Figure 3.3**).

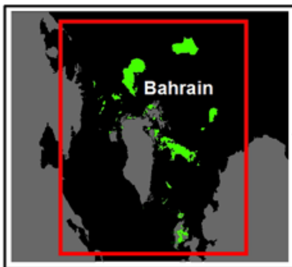




Title: Potential Industrial Growth and Industrial Corridor (Adapted from NPDS Bahrain 2030, The National Plan)	Client: Bapco Technip
Project: Bapco Modernization Program	
Date: June 2016	Figure No.: 3.1
Datum: WGS 84 - UTM 39 N	Scale: 1:250,000 @ A4
Consultant: Environment Arabia	

CN:\Bapco Modernisation Plan\mxd\Landuse maps\Industrial corridor.mxd





Title: Marine Policy Zone and Regional Coastal Cells		Client: Bapco Technip
Project: Bapco Modernization Program		
Date: June 2016	Figure No.: 3.2	Consultant: Environment Arabia
Datum: WGS 84 - UTM 39 N	Scale: 1:500,000 @ A4	

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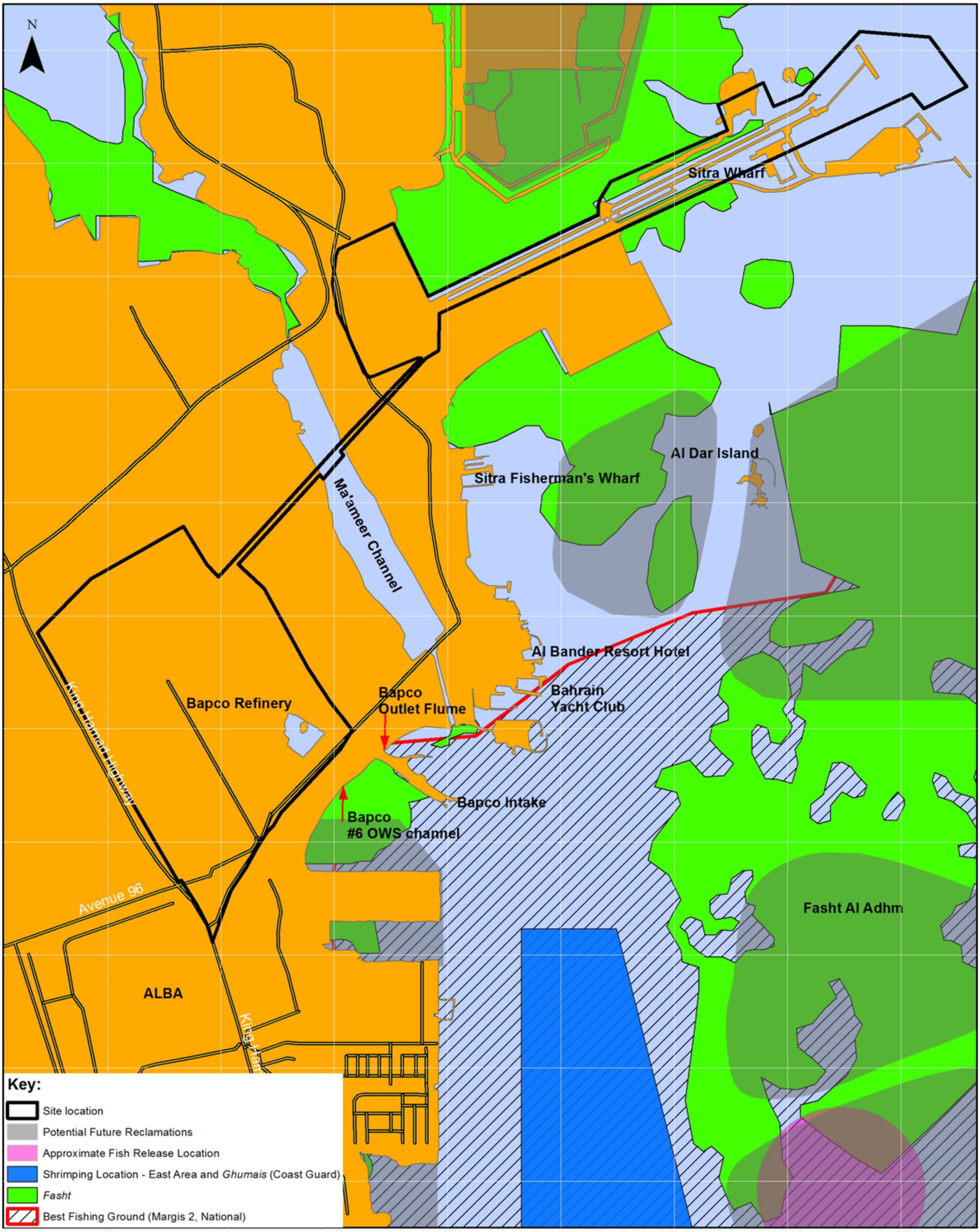

Title:	Coastal Developments and Fisheries Interest in relation to Bapco Modernisation Project
Project:	Bapco Modernization Program
Date:	June 2016
Figure No.:	3.3
Datum:	WGS 84 - UTM 39 N
Scale:	1:45,000 @ A4
Client:	Bapco, Technip
Consultant:	Environment Arabia

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3.3 Adjacent Land Use and Coastal Developments

The proposed BMP is located on the eastern coast of Bahrain within an area designated as a priority industrial corridor in the National Plan. The proposed BMP comprises large tracts of land to the south and east of the existing Bapco Refinery. It also includes selective areas within the Sitra Tank Farm and Sitra Wharf located north of the main Refinery. **Figure 3.4** presents the current land use based on a review of local maps and a land use survey undertaken in the study area on 29th July 2015. Land in the immediate vicinity of the BMP site is largely used for industrial and commercial purposes. Representative sensitive receptors within the identified landuse zones presented on **Figure 3.4** have been selected for the specialist assessments for the ESIA. A description of the sensitive receptors and the rationale behind the selection is presented in **Table 3.2**.

Table 3.2 Sensitive Receptors

Reference No. from Figure 3.4	Description	Notes
1	Al Noor International School	School to the north of the proposed site on Sitra Island
2	East Sitra Housing Development	Large proposed residential area to the north of the wharf, and north east of Sitra Tank Farm.
3	Sitra Residential Area	Closest residential area to Sitra Tank Farm.
4	Nuwaidrat Residential Area	Closest village to the north of the BMP site.
5	Eker	Village approximately equidistant to Sitra Tank Farm and the BMP site.
6	Umm Alqura Primary Girls School	Representative of a school receptor within residential areas to the north of the BMP site.
7	Ma'ameer Village	Residential area between Sitra Tank Farm and the BMP site.
8	Residential/Apartments	Closest residential units to BMP site.
9	Bahrain Yacht Club/Al Bandar	Representative recreation/tourist land use east of BMP site.
10	Residential	Closest residential receptor to west of BMP site.
11	Residential	Closest residential receptor to south of BMP site.
12	East Riffa Residential Area	Residential area to the north west of BMP site.
13	International Medical City Hospital	Representative of healthcare receptor in study area.
14	Riffa Views	Representative of recreation/residential receptor to the west of the BMP site.

Environment Arabia

The Aluminium Bahrain plant is located to the south, beyond which is the South Alba Industrial Estate with a wide variety of heavy, light and high-tech industries. To the west is an open tract of land that is criss-crossed by oil and gas pipelines. In the north is the Riffa Power Station and the Ma'ameer and Sitra industrial estates. To the east of the tank farm is the GPIC plant and the Alba Calciner plant.

Ma'ameer village, the nearest residential community to the Refinery, is located adjacent to the northern perimeter of Bapco, beyond which are the villages of Eker and Nuwaidrat over a kilometre away. The closest residential community to the south of the Refinery is Askar at approximately 5 km). The large residential community of Riffa lies approximately 1 km north west of the Refinery. Furthermore, the villages of Murqoban, Wadiyan, and Abu Alayash are all located on Sitra island just 1-3 km north of the Sitra Tank Farm.

Labour accommodation blocks are scattered around the adjacent industrial areas to the north and south of the Refinery. Labour blocks have been observed within the Alba plant, the South Alba Industrial Estate, and the Ma'ameer and Sitra Industrial areas. There is also a labour accommodation block approximately 300 m to the west of the Pitch Ponds site.

There are few remaining areas of natural coastal strip in the study area as they have been significantly affected by industrial development. However, there is a strip to the south of the Pitch Ponds and Refinery which is still in a relatively natural state. This area has been surveyed as part of the terrestrial ecological survey.

The National Mariculture Centre (NMC) is located approximately 7 km to the south in Ras Hayyan. The NMC is responsible for periodic releases of fish stocks in *fasht Al Adhm*.

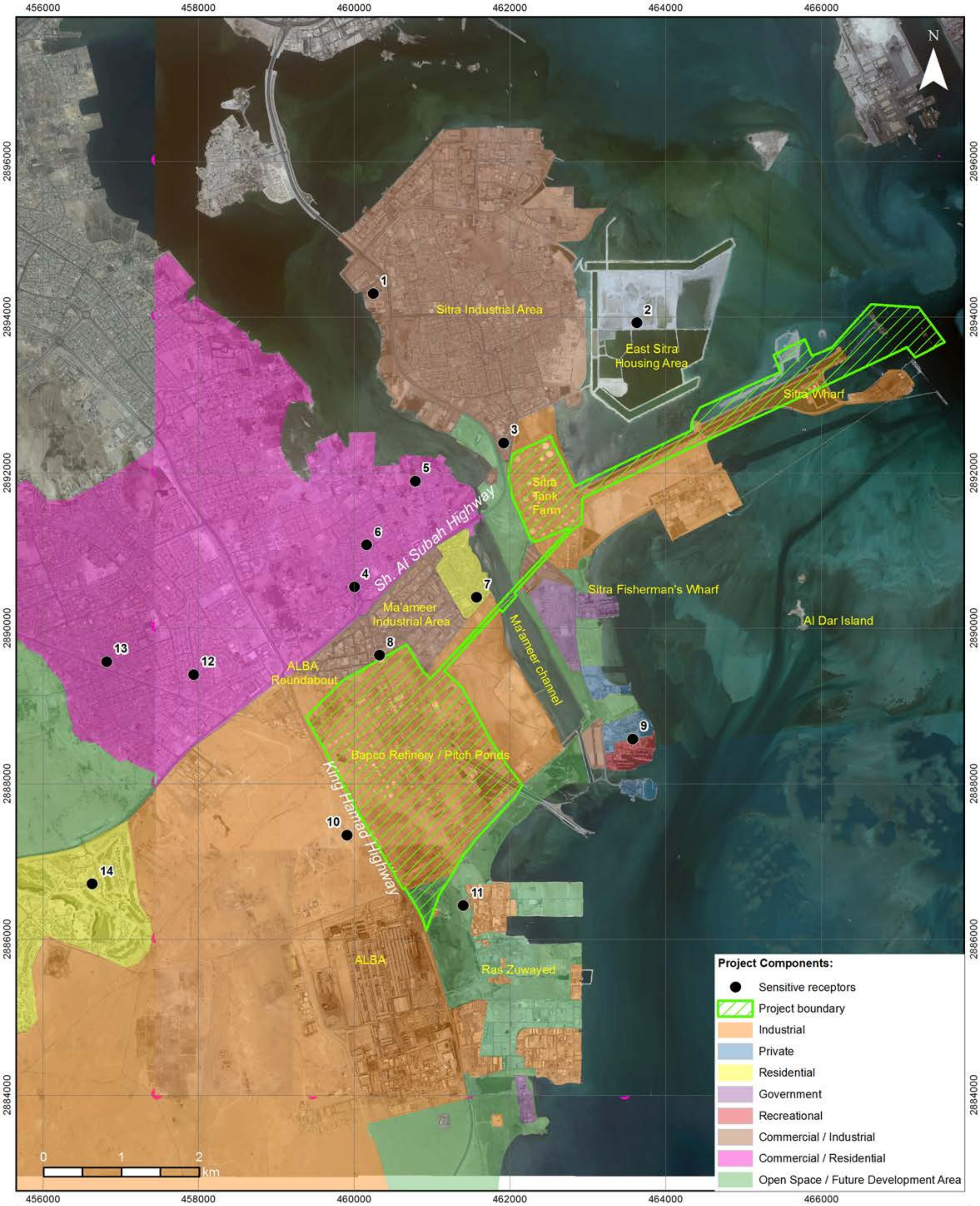
Sitra Fishing Harbour, Askar jetty and private jetties have been highlighted in **Figure 3.3**. Bahrain Yacht Club and Al Bander Resort Hotel are the nearest tourism and recreation facilities approximately 1 km north of the Bapco Refinery water intake (**Figure 3.5**). Al Dar island is approximately 3 km from the southern boundary of Sitra Tank Farm.

Several outfalls can be found at a number of industrial plant surrounding the Refinery and tank farm, e.g. discharges from GPIC, Ras Abu Jarjoor Desalination Plant, Mariculture Centre, etc.). There are two outfalls associated with the Bapco Refinery, and these are shown on **Figure 3.5**.

3.4 References

(Alba, 2015) News item on Alba website retrieved 28.03.16 http://www.albasmelter.com/mc/News/Pages/2015/Alba-receives-environmental-permission-for-L6.aspx

(MoMA, 2007) Bahrain 2030 The National Plan, Produced by the National Planning Development Strategies Team on behalf of the Economic Development Board, Ministry of Municipalities and Agriculture, 2007.



Title: **Adjacent Land Use and Sensitive Receptors**		Client: Bapco Technip
Project: Bapco Modernization Program		
Date: June 2016	Figure No.: 3.4	Consultant: Environment Arabia
Datum: WGS 84 - UTM 39N	Scale: 1:60,000 (A4)	

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Title: Relevant Intake and Outfalls in the Study Area

Project: Bapco Modernization Program

Date: June 2016

Figure No.: 3.5

Datum: WGS 84 - UTM 39 N

Scale: 1:50,000 (A4)

Client: Bapco Technip

Consultant: Environment Arabia

CN:\Bapco Modernisation Plan\mxd\Landuse maps\Existing Outfalls.mxd

4 ESIA METHODOLOGY

4.1 Terminology

National legislation in Bahrain refers to "Environmental Effects Evaluation" and "Environmental Impact Assessment" (EIA). For this report, this is identified as synonymous with the process of "Environmental and Social Impact Assessment" referred to in the international guidance referenced.

4.2 Legal Requirement for ESIA in Bahrain

The ESIA is to be undertaken in accordance with '*Ministerial Order No. 1 of 1998 with Respect to the Environmental Evaluation of Projects*'. In Bahrain, the ESIA process results in the preparation of a report which provides a review and assessment of all activities and potential significant impacts related to the project.

In accordance with Article 7 of '*Ministerial Order No.1 of 1998'* the report should provide:

- The complete and precise description of the project.
- The justification for establishing the project from an economic and social perspective.
- The objectives of the project.
- Project establishment.
- Results arising from its execution in general and on the natural resources and safety in particular.
- Procedures to be adopted to protect the environment.
- The programme for detecting emissions resulting from the project.
- A comprehensive description of the environmental situation which may be affected by the project and details of the reactions in all stages with this situation and analysis of the environment reactions resulting from it in these stages.

Typically, the ESIA process in Bahrain follows a systematic approach encompassing the entire development from construction to decommissioning within the following key phases:

- Submission and review of environmental screening forms (e.g. EA-2).
- Production and review of an ESR.
- Production and submission of a draft evaluation report.
- Submission of final evaluation report.
- Production of Environmental Management Plan(s) (EMPs).

The objectives of the ESIA are:

- ➢ To aid in the decision-making process by providing a systematic assessment of the environmental implications of the proposed project, and possible alternatives (e.g. techniques, methods) before a decision is made.

- To identify adverse and beneficial impacts of the development during construction and operation.
- To recommend mitigation measures and formulate an action plan for any adverse impact that will arise as a result of the development.

4.3 International Guidance

The BMP will be an international project. Material and finance will be obtained from global as well as local suppliers. To ensure that environmental and social risks are adequately addressed on major international projects, such as the BMP, the international trade and finance community has developed a set of guidance documents which are summarised in the following sections.

4.3.1 International Finance Corporation and World Bank

4.3.1.1 Performance Standards on Environmental and Social Sustainability

The Sustainability Framework of the International Finance Corporation (IFC, 2012) includes the Policy and Performance Standards on Environmental and Social Sustainability. The Policy describes the IFC's commitments, roles and responsibilities related to environmental and social sustainability. The Performance Standards are directed towards clients[4], providing guidance on how to identify risks and impacts, and are designed to help avoid, mitigate and manage risks and impacts as a way of doing business in a sustainable way, including stakeholder engagement and disclosure obligations of the client in relation to project-level activities. The Performance Standards can also be applied by other financial institutions. There are eight Performance Standards as follows:

PS 1: Assessment and Management of Environmental and Social Risks and Impacts
PS 2: Labour and Working Conditions
PS 3: Resource Efficiency and Pollution Prevention
PS 4: Community Health, Safety and Security
PS 5: Land Acquisition and Involuntary Resettlement
PS 6: Biodiversity Conservation and Sustainable Management of Living Natural Resources
PS 7: Indigenous Peoples
PS 8: Cultural Heritage

Performance Standard 1 applies to all projects that have environmental and social risks and impacts. Depending on project circumstances, the other Performance Standards may apply as well. The applicability of Performance Standards 2 to 8 is established during the environmental and social risks and impacts identification process.

In addition to meeting the requirements under the Performance Standards, clients must comply with applicable national law, including those laws implementing host country obligations under international law.

[4] The term client is used throughout the Performance Standards broadly to the party responsible for implementing and operating the project that is being financed, or the recipient of the financing.

4.3.1.2 World Bank Environmental, Health and Safety Guidelines

The World Bank Environmental, Health and Safety (EHS) Guidelines are technical reference documents with general and industry-specific examples of good international industry practice. The IFC uses the EHS Guidelines as a technical source of information during project appraisal. The EHS Guidelines contain the performance levels and measures that are normally acceptable to IFC, and that are generally considered to be achievable in new facilities at reasonable costs by existing technology. The environmental assessment process may recommend alternative (higher or lower) levels or measures, which, if acceptable to IFC, become project- or site-specific requirements.

When host country regulations differ from the levels and measures presented in the EHS Guidelines, projects are expected to achieve whichever is more stringent. If less stringent levels or measures are appropriate in view of specific project circumstances, a full and detailed justification for any proposed alternatives is needed as part of the site-specific environmental assessment. This justification should demonstrate that the choice for any alternative performance level is protective of human health and the environment.

The following guideline documents are directly relevant to the BMP:

- General EHS Guidelines (World Bank, 2007a).
- Environmental, Health, and Safety Guidelines for Petroleum Refining (World Bank, 2007b).
- Environmental, Health, and Safety Guidelines for Crude Oil and Petroleum Product Terminals (World Bank, 2007c).

4.3.1.3 World Bank Operational Policy 4.01 - Environmental Assessment, Revised April 2013 (World Bank, 2013)

For internal purposes the World Bank screens projects in respect of their environmental impact into 3 categories:

- Category A – the project is likely to have significant adverse environmental impacts that are sensitive, diverse, or unprecedented. These impacts may affect an area broader than the sites or facilities subject to physical works. A full EIA is required.

- Category B – the potential adverse environmental impacts on human populations or environmentally important areas--including wetlands, forests, grasslands, and other natural habitats--are less adverse than those of Category A projects. The impacts are site-specific; few if any of them are irreversible; and in most cases mitigatory measures can be designed more readily than for Category A projects. A narrower scope, more limited EIA is required.

- Category C – the project is likely to have minimal or no adverse environmental impacts. Beyond screening, no further EA action is required for a Category C project.

For this project we have considered the BMP is likely to classed as a Category A project in that it is an extensive, high-value industrial project that is likely to have both on and off-site environmental impacts.

4.3.2 Equator Principles III (June, 2013)

The Equator Principles are a set of voluntary standards adopted by many banks that were originally developed in 2003 by IFC. The third iteration was published in 2013. They are used by the financial industry for assessing and managing environmental and social risk when providing loans to finance major industrial and infrastructure projects. The Equator Principles reference the IFC EHS guidelines as required project performance standards.

The Equator Principles classifies projects for the purposes of EIA using the same classification system as that stated above for the World Bank.

4.3.3 OECD Common Approaches

The OECD Common Approaches (OECD, 2012) are a set of requirements applied to projects that seek financial support from OECD Export Credit Agencies (ECAs). The requirements seek to harmonise procedures for environmental and social due diligence amongst ECAs and to provide a framework for taking decisions on the nature of environmental and social risks. They are underpinned by the IFC Performance Standards and other technical standards (e.g. EU requirements and standards).

4.3.4 European Union

The European Union publishes guidance documents on pollution control techniques for various industry sectors. These documents define "Best Available Techniques" (BAT) for abating emissions from industrial plant. In respect of refineries the following document is applicable: Best Available Techniques (BAT) Reference Document for the Refining of Mineral Oil and Gas Industrial Emissions Directive 2010/75/EU Integrated Pollution Prevention and control EUR 27140 EN 2015 (BREF, 2015).

4.4 Stages within the ESIA Process

Typically, the EIA process in Bahrain follows a systematic approach encompassing the entire development from construction to decommissioning (as appropriate) following the stages presented in **Figure 4.1**. These stages of work have been developed as a result of consultation with the SCE and represent a 'best practice' approach. This ESIA Report is the principal document within the ESIA process. It reports on the findings of the ESIA process, offering solutions and recommendations to ensure that identified impacts are mitigated. The final stage should be undertaken on commencement of construction.

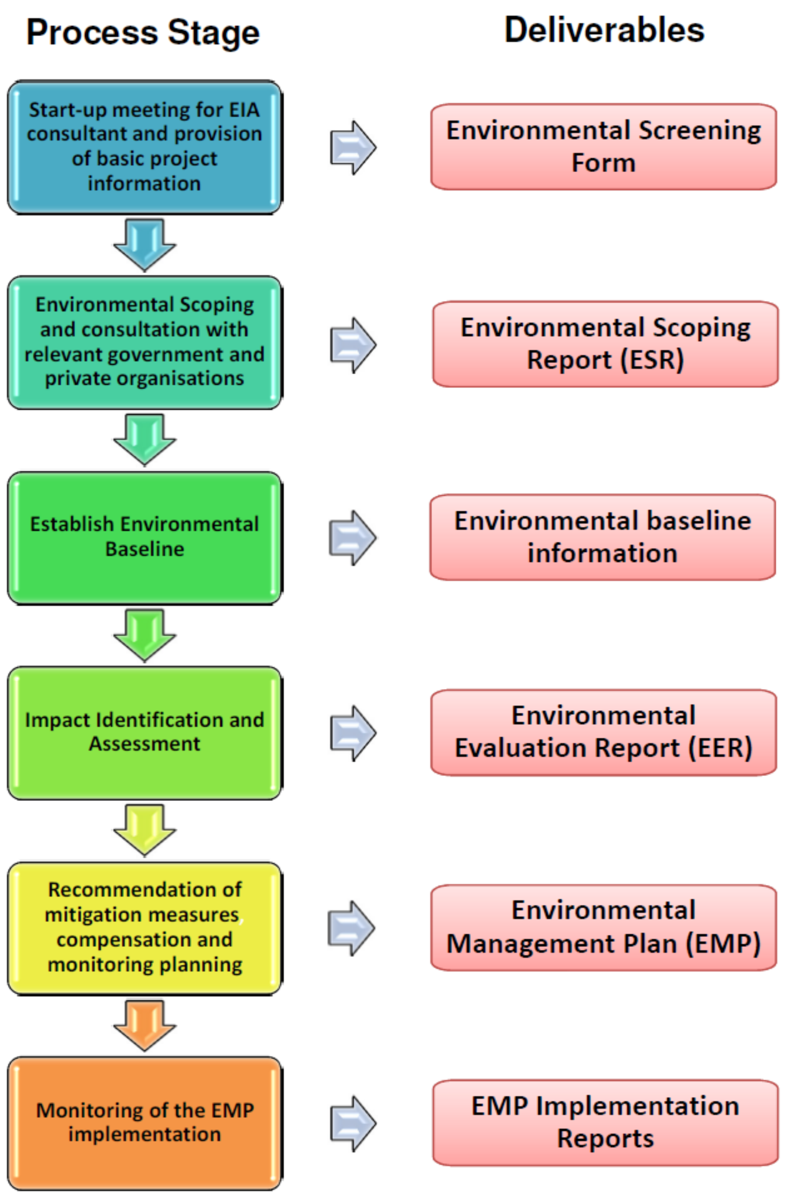
4.5 Environmental Screening

The EA-2 Environmental Screening Form for the BMP was submitted to the SCE on 12th August 2015. A response from them was received on the 1st November 2015. The response to the screening form is provided in **Appendix 5B**.

The screening response indicated that in accordance with Ministerial Order No.1 of 1998 regarding Environmental Assessment, the proposed project is subject to pass through the Environmental Impact Assessment process and should follow the general guidelines for ESIA Scope (EIA-2). The response indicated that a comprehensive environmental impact assessment was required.

The assessment of potential health impacts will not extend beyond that stated within the Environmental Scoping Report, and is related to those potential impacts arising from construction activities and operation of the new Refinery units (e.g. health impacts associated with a potential reduction in air or water quality) and their effects upon both construction personnel and the general public. Any impacts are likely to be mitigated via best practice (e.g. use of appropriate PPE and to adherence to relevant environmental standards/guidelines).

Figure 4.1 Stages in the ESIA Process



4.6 Environmental Scoping

As part of the scoping process, readily available secondary data was compiled and reviewed to provide a good understanding of the baseline environmental conditions in the area. Consultations with Government and Non-Government organizations formed an important part of the scoping exercise and a large number of meetings with stakeholders were held during the scoping phase and throughout the ESIA process. Stakeholder engagement is discussed further in **Section 5**. The scoping report presented the methodologies for the specialist studies required for the assessment phase. Furthermore, relevant policies, guidelines and legislation, together with industry-accepted practice were identified at this stage. The BMP Environmental and Social Impact Assessment Scoping Report was submitted to the SCE on 14th December 2015.

Based on the outcome of the Environmental and Social Scoping Study, the parameters listed in **Table 4.1** have been studied in this ESIA. Each environmental parameter is presented in separate sections of this report which consider: legislation & guidance, baseline conditions, impact of development, mitigation measures and any monitoring requirements.

Table 4.1 ESIA Parameters Investigated

Parameters	Section
Air Quality	6
Soil and Groundwater	7
Noise	8
Hydrodynamics and Water Quality	9
Sediment Quality	10
Marine Ecology	11
Terrestrial Ecology and Avifauna	12
Cultural Heritage and Archaeology	13
Traffic and Access	14
Waste	15
Chemicals	16
Energy Efficiency	17
Social and Community Impacts	18
Labour and Working Conditions	19
Occupational Health and Safety	20

4.6.1 Environmental Baseline

Baseline studies have established the current baseline conditions, i.e. the environmental conditions that exist in the vicinity of the proposed project and across the study areas for each topic. These studies comprised a mixture of desk-top research to gather and evaluate previous environmental work and publically available information, together with new environmental surveys and consultation with local groups.

4.6.2 Area of Influence

The project Area of Influence (AOI), in respect of its environmental and social impacts, is defined on a subject by subject basis within this ESIA. In some cases such as assessment of environmental noise impacts, the AOI is relatively small and is constrained to the immediate vicinity of the project site. For other subjects such as air quality, the AOI is much larger as emission to air can impact ground level air quality at significant distance from the project site. In each subject chapter, the relevant AOIs are defined

4.6.3 Assessment of Impacts

Assessment of the impacts of the proposed project has been undertaken in accordance with international industry best practice. The assessment has identified both beneficial and adverse impacts on environmental resources or receptors, and has assessed whether the resulting effects are considered to be significant. The likelihood that an impact will give rise to a significant environmental effect depends on a number of factors, such as the magnitude of the impact, the extent of the impact and the sensitivity of the receiving environment.

The predicted impacts and effects have generally been classified according to whether they are beneficial, adverse or negligible. They have further been categorized as minor, moderate or major as presented in **Table 4.2**.

The duration of the impacts have been defined as either temporary or permanent, and direct or indirect. Where it is not possible to quantify impacts, qualitative assessments have been carried out, based on professional judgment. Where uncertainty exists, and assumptions have had to be made, these are explained in the specialist sections of this ESIA report.

Table 4.2 Impact Significance Levels

Impact Significance	Impact Characteristic
Major Beneficial	The impact is large scale, giving rise to a significant gain to the environment.
Moderate Beneficial	The impact would provide a positive gain to the environment.
Minor Beneficial	The impact is small and would have a slight benefit to the environment.
Negligible	Either no impact or the impact is neutral (neither adverse nor beneficial).
Minor Adverse	The impact is small and of little concern; it is undesirable but acceptable.
Moderate Adverse	The impact gives rise to some concern but is likely to be tolerable in the short-term (e.g. during the construction phase) or would require a value judgement as to its acceptability.
Major Adverse	The impact is large-scale, giving rise to great concern; it should be considered unacceptable and requires mitigating, compensating or a significant change to the development if no alternative is available. If no mitigation is possible, then the impact would require a value judgement as to its acceptability.

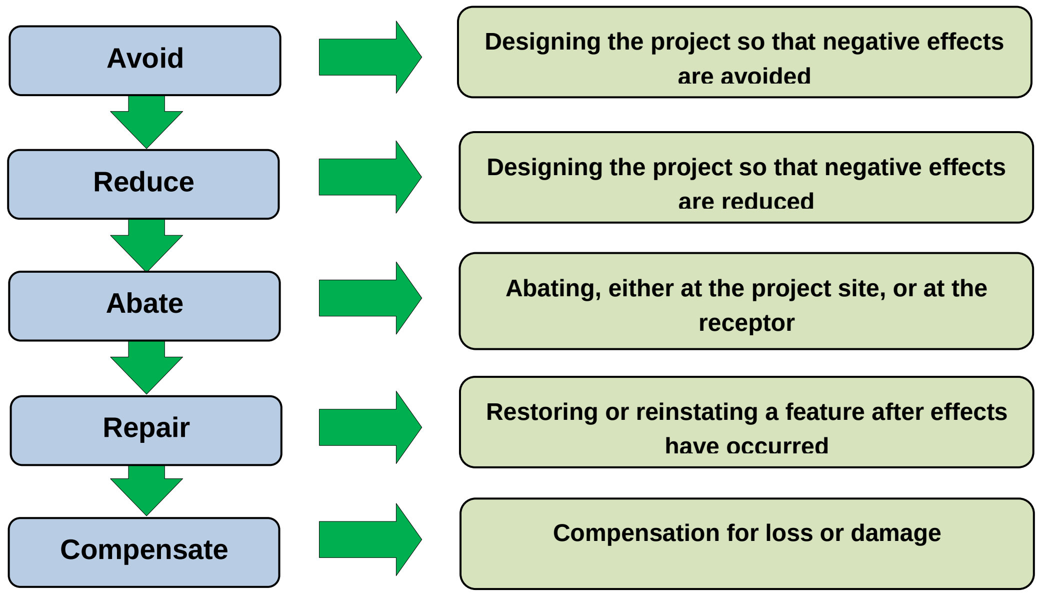
Effects deemed to be significant have been evaluated against recognised standards and accepted criteria for each environmental topic, where these are available. Where no recognised standards or criteria exist, professional judgment has been used, taking into account factors such as:

- Spatial extent;
- Magnitude;
- Duration (short, medium, long-term);
- Frequency of occurrence;
- Nature of effect (direct, indirect, permanent or reversible);
- Whether it is cumulative;
- Sensitivity and numbers of receptors affected;
- Performance against environmental quality standards; and
- Compatibility with environmental policies.

4.6.4 Approach to Mitigation

The ESIA process requires the assessment report to include a description of the measures envisaged in order to avoid, reduce and, if possible, remedy significant adverse effects. Such measures are described in sections on mitigation within the specialist sections of this report. The approach to mitigation has a hierarchy whereby priority has been given to avoiding or preventing effects and then, if this is not possible, to reducing or abating them, and then, if necessary, to offsetting them through repair (restoration or reinstatement) or compensation. The hierarchy is illustrated in **Figure 4.2**.

Figure 4.2 Mitigation Hierarchy



The types of mitigation measures presented will either be design mitigation or mitigation requiring additional features to be added to the project, e.g. screening for noise impacts, or mitigation thorough monitoring and compensation programs.

4.7 References

(BREF, 2015) Best Available Techniques (BAT) Reference Document for the Refining of Mineral Oil and Gas Industrial Emissions Directive 2010/75/EU Integrated Pollution Prevention and control EUR 27140 EN 2015.

(Equator Principles III, June, 2013) http://www.equator-principles.com/index.php/ep3. Accessed 29th May 2106.

(IFC, 2012) Performance Standards on Environmental and Social Sustainability. International Finance Corporation 2012. http://www.ifc.org/performancestandards. Accessed 29th May 2106.

(OECD, 2012) OECD Common Approaches. Revised text for the Recommendation of the Council on Common Approaches for Officially Supported Export Credits and Environmental and Social Due Diligence (the "Common Approaches"), as adopted by the OECD Council on Wednesday 6 April 2016: TAD/ECG(2016)3.

(World Bank, 2007a) General EHS Guidelines. http://www.ifc.org/ehsguidelines. Accessed 29th May 2106.

(World Bank,: 2007b) Environmental, Health, and Safety Guidelines for Petroleum Refining. http//www.ifc.org/ehsguidelines. Accessed 29th May 2106.

(World Bank, 2007c) Environmental, Health, and Safety Guidelines for Crude Oil and Petroleum Product Terminals. http://www.ifc.org/ehsguidelines. Accessed 29th May 2106.

(World Bank, 2013) World Bank Operational Policy 4.01 - Environmental Assessment, Revised April 2013. http://go.worldbank.org/OSARUT0MP0. Accessed 29th May 2106.

5 STAKEHOLDER ENGAGEMENT

5.1 Overview

The process of ESIA in Bahrain requires consultation with stakeholders at the scoping stage and through the preparation of the ESIA Report. In this case, EACS, alongside Bapco and TPIT, have led a stakeholder engagement process that has been undertaken in stages as presented in the following sections. Prior to EACS commencement of the ESIA, Bapco have also undertaken on-going consultations with the SCE and this activity is also summarised in this section.

5.2 Identification of Stakeholders

There are five key constituents of stakeholders that have been identified for the BMP:

1) National government officials– the BMP is a nationally important project that will require the co-ordinated input from multiple government ministries and their agencies. A key part of the stakeholder engagement process has been to introduce these ministries and agencies to the BMP and seek feedback in respect of their concerns and knowledge of planned developments.

2) National Government and leadership advisory bodies – the National Assembly comprises: The Council of Representative (the lower house); and the Consultative Council or Shura Council (the upper house).

3) Supreme Council for Environment (SCE) – the national environmental authority who will be responsible for permitting the BMP.

4) Local government – consists of the Southern Governorate, the Southern Municipality and Southern Municipal Council, which is an elected body.

5) Non-Governmental Organizations – Organizations of Bahrain civil society with an environmental remit.

5.3 Stakeholder Engagement Process

The process comprises informing consultees regarding the scope of the BMP and its anticipated environmental impacts and then collection and collation of their responses. Once these have been obtained, if there are any specific impacts of concern identified, then the design and management proposals for the BMP have been checked and reviewed to determine if any improvements or changes can made to mitigate the impact, or if any further information can be provided to address the concerns raised.

The process has been documented throughout. All stakeholders have been invited to meetings in writing. At the time of invitation, a Project Information Sheet (PIS) (**Appendix 5A**) was provided to the stakeholders to give them a brief overview of the project prior to the meeting to allow them to prepare. All stakeholder meetings have been minuted and a copy of the minutes supplied to the stakeholder for comment before finalising them. Copies of all meeting minutes are included in **Appendix 5A**.

5.4 Stakeholder Engagement with National Government

5.4.1 Consultation Meetings and Responses

The first phase of consultation was undertaken during the preparation of the project scoping report. Consultations were held with national government ministries and agencies. The purpose of these consultations was to identify possible interactions and constraints in respect of other planned development programs and projects and to identify possible environmental constraints on the BMP.

A list of the organisations that were consulted with is provided in **Table 5.1**, including the contact name and a summary of responses received. The consultation process began during the scoping phase of the study and continued during the ESIA stage. **Appendix 5A** contains the minutes of meetings.

Table 5.1 Summary of National Government Consultations

Organisation	Main Contacts	Notes
Agricultural Affairs and Marine Resources (AAMR)	Abdulla Abdullatif (Director General) Ibtisam Abdulla (Director of Fisheries) Bassam Al Showaikh (Senior Marine Biologist)	*Consultation undertaken on 14th October 2015 at AAMR, Old Juffair, Manama* *Response received 26.10.2015:* • The designated area is surrounded by major fishing grounds. • Information is required regarding the technologies to be used to minimise levels of pollution in the marine environment. • If any aspects of the BMP affect sedimentation in the Ma'ameer channel, mitigation measures would need to be provided. • The AAMR requested copies of historical work undertaken by Dr Olof Linden. These have been issued by Bapco. The AAMR attended a presentation on the 2015 survey in March 2016. • The AAMR must be informed of any reclamation activities.
Agriculture, Engineering and Water Resources Directorate (AEWRD)	Ali Hameed Al-Shabaani (Acting Director) Marcial A. Mojica (Senior Hydrogeologist)	*Consultation undertaken on 9th October 2015 at AEWRD, Budaiya* • The AEWRD enquired how long AGAS has been working on the Pitch Ponds, and EACS stated that it was approximately 15 years. Most of the pitch has been removed but more pitch needs to be recovered from ponds adjacent to the BMP site. Residual pitch remains on the site which will be covered with clean material with a depth of 3-4m to raise the height of the site to be in-line with the existing Refinery. • AEWRD requested hydrogeological data from previous site investigations undertaken at the Refinery and Sitra Tank Farm by EACS on behalf of Bapco

Organisation	Main Contacts	Notes
		• SI data will be provided to the AEWRD as part of the ESIA from historical and more recent investigations. • A geotechnical survey has just been completed of the Pitch Ponds sites and the AEWRD had requested a copy as part of permitting the work. • The AEWRD stated that there are no production wells in the vicinity of the BMP site, but Bapco itself abstracts from Aquifer C. • No abstraction is proposed as part of the BMP, but seawater will be used for cooling purposes following desalination. • The AEWRD will require long-term monitoring of the BMP site. At least two wells should be provided near the Pitch Ponds site. These should be located in areas which allow the AEWRD direct access. • The AEWRD requested that a site visit be conducted to the Pitch Ponds site during the ESIA. • The AEWRD asked whether there would be any piling for the tanks and reminded EACS that a permit would be required for any piling operations. *Site Visit undertaken on 20th October 2015 with representatives from the AERWD, Bapco and Environment Arabia.*
Bahrain Authority for Culture and Antiquities	Shaikha Azza Al Khalifa (Assistant Undersecretary)	*Consultation letter sent on 20th September 2015.* Shaikha Azza received letter and advised EACS that she is waiting for advisor to the Authority to respond. Response received via e-mail on 10th of January requesting a walkover survey to be undertaken to the part of the BMP site which was of interest to the authority. The survey was undertaken on 12th January 2015 with the presence of EACS staff.
Central Planning Office (CPO), Ministry of Works	John Fisher (Head, Advisory and Coordination) Ali Bucheery (Environmental Engineer)	*Consultation letter sent on 20th September 2015* The CPO verbally stated on 7th October 2015 (telecom between Ali Bucheery and Halel Engineer) that they had no comments and did not need a consultation meeting. No written response received to date.
Coastguard Directorate, Ministry of Interior (CG)	Colonel Yusuf Mohammed Al Subaie (OC Legal Affairs)	*Consultation undertaken on 30th September 2015, Coastguard Headquarters, Sitra* • Colonel Subaie indicated that the area where the Bapco Wharf is currently located is considered a sensitive area in terms of security due to the existence of nationally important industrial facilities and Sitra port, and the navigation of

Organisation	Main Contacts	Notes
		vessels within that area. • Colonel Subaie expressed the need to inform the Ministry of Interior, the National Guard, the CID, Alba and Bapco security Departments of this project with coordination by NOGA. He suggested that a joint stakeholder meeting should be set up so that the concerns of all parties could be addressed. Bapco has sent letters to all aforementioned parties informing them of the project. • A contact for Bapco was requested. • The Coastguard should be provided with details of marine operations as soon as they become available (e.g. date & time of operation, type of boat, crew, etc.).
Electricity and Water Authority (EWA)	Shaikh Nawaf Bin Ebrahim Bin Hamad Al Khalifa (Chief Executive Officer)	*Consultation undertaken on 14th October 2015, Diplomatic Area* Minutes in draft form – comments yet to be provided.
General Directorate of Civil Defence	Bassam Khalaf Head of Protection and Safety	*Consultation undertaken on 7th October 2015, Block 313* • CDD expressed that they have no comments or concerns regarding the BMP project at this stage, and that they are happy with Bapco safety standards and regulations that will be followed.
Ministry of Municipalities Affairs and Urban Planning (MMAUP) (General Directorate of Urban Planning (GDUP))	Khalid Ahmed Al Ansari (Structural Planning Director) Mohamed Adel Aburowais (Coastal Engineer) Virgilio Perada (Urban Planning Advisor)	*Consultation undertaken on 8th October 2015, GDUP, Zayed Town* • GDUP indicated that they are concerned with the possible reclamation associated with the transfer pipelines from the Refinery to Sitra Tank Farm within the Ma'ameer channel and that it is unlikely that such an element of the project will obtain approval. They suggested looking at alternative methods of pipe crossing. They also indicated that there is a committee tasked with providing a solution to the existing issues with flushing and retention time of water within Tubli Bay. Widening of both the northern and southern extents of the Ma'ameer channel is being discussed.
Ministry of Transport and Telecommunications (MoTT)	Didar Dalkic (Advisor to the Minister)	*Consultation undertaken on 12th October 2015, Bahrain Financial Harbour, 9th Floor East Tower* • The MoTT stated that there may be a railway in the vicinity of the Refinery and that they would provide a drawing showing an indicative route. The route currently indicated follows the Sh. Jaber Highway and crosses the Ma'ameer channel just north of the existing transfer pipes. If the East Sitra Road Link is provided by the Roads Directorate, opportunities for the railway

Organisation	Main Contacts	Notes
		along this corridor would be investigated. The development of the railway is dependent on the construction of the Bahrain to Qatar Causeway. • A planning application was circulated for the railway following Shaikh Jaber Highway approximately 18 months ago. The MoTT stated that they will check their records to see whether Bapco responded with comments on the application. A response can be expected in a few weeks time. • The MoTT stated that they had no concerns with the tabled plans for the BMP.
Ports and Maritime Affairs (PMA)	Essa Abdulla Yateem (Acting Assistant Undersecretary, Maritime Affairs)	*Consultation undertaken on 6th October 2015, PMA in Hidd* • The PMA enquired whether the BMP project was linked to the A/B pipeline and it was explained that both projects are part of the overall expansion of Bapco. • The PMA enquired of the Bapco Pitch Ponds were cleared and how deep the residue was. It was explained that approximately 80% of the pitch has been removed and two recent site investigations have been undertaken to determine site conditions, the results of which will be reported in the ESIA. • The PMA expressed that their interest lies in the marine element of the project more specifically regarding any changes in the wharf equipment, pipelines and navigational channels. It was explained that 19 new loading arms will be provided at the wharf and a new pipeline will be required at the end of the wharf. • PMA stated that all ships must comply with the requirements of the Marpol convention. • The PMA expressed their concern for any increase in discharge or oil spill in the marine environment. EACS noted that that discharges from the Refinery outfalls will be within the design limits of the existing treatment plants.
Roads, Planning & Design Directorate (RPDD), Ministry of Works	Huda Fakhroo (Assistant Undersecretary) Kadhim Ali A. Latif (Director)	*Consultation undertaken on 6th October 2015, Ministry of Works, Government Avenue* • The Roads Directorate has appointed a consultant to undertake the design of improvements to Sh. Jaber Highway from Um Al Hassam Interchange to Nuwaidrat roundabout. The improvements will include more lanes and grade separated junctions. A plan was provided. • The Roads Directorate intends to construct a new road linking Mina Salman to King Hamad Highway via East Sitra, known as East Sitra Link Road. This project is at the feasibility stage and

Organisation	Main Contacts	Notes
		they have invited consultants to bid for studying the potential impact of the road on concerned stakeholders in the area such as NOGA, GPIC, Bapco & Alba. • Construction work is about to commence on the Alba and Nuwaidrat roundabouts. Some preliminary work is underway on moving the affected utilities. Plans for the roundabouts were provided. • The Roads Directorate also plans to upgrade King Hamad Highway in the future. There will be 3-4 lanes in each direction together with grade separated junctions. • The Roads Directorate has no concerns regarding the BMP project, but they wish to know whether the AGAS plant will be removed in the future.
Sanitary Engineering Projects and Planning Directorate (SEPPD), Ministry of Works	Asma Murad (Acting Assistant Undersecretary)	Consultation was undertaken on 11th November 2015 during a meeting which was held in the SEPPD offices in Salmabad. The following points were raised: • SEPPD presented EACS with the plan for a proposed TSE pipeline from the Ma'ameer STP. SEPPD does not feel that this proposed line would conflict with the BMP project. However, SEPPD indicated that they have plans to construct a STP on the East Sitra Housing project with outfalls potentially parallel to the Sitra Wharf. • SEPPD suggested that Bapco use the TSE from Ma'ameer STP for landscaping or beautification purposes as it is high quality TSE. The current plan is to use this TSE for landscaping the King Hamad Causeway.
Supreme Council for Environment (SCE)	Luma Abbas Al Mahroos (Head of Environmental Assessment)	*Initial consultation undertaken 5th October 2015 at SCE* Consultations are ongoing. Please refer to Section 5.5.

5.5 Consultations with the Supreme Council for Environment

5.5.1 BMP Consultation

Table 5.2 summarizes the consultation history with the SCE regarding the BMP. Copies of letters and minutes of meetings are included in **Appendix 5B**.

Table 5.2 Consultations with the SCE

Date	Activity	Outcome
12/08/15	Submission of Environmental Screening (EA-2) Form (by Bapco)	
17/09/15	Submission of letter to SCE introducing the BMP and requesting a consultation meeting	
05/10/15	Consultation meeting with SCE	Meeting to introduce the BMP (see **Appendix 5B**).
01/11/15	SCE response letter to ESIA Screening Form	Confirmed requirement for preparation of a full ESIA (see **Appendix 5B**).
14/12/15	Submission of ESIA Scoping Report to SCE	
9/02/16	Meeting with SCE to provide an update of ESIA progress and program.	Not minuted. SCE updated regarding environmental baseline surveys including intention to submit ESIA with 3 months of air quality monitoring data and then provide a supplementary air quality monitoring report for months 4-6 at a later date.
11/02/16	Visit to the site of the AQMS.	
25/02/16	SCE response letter to ESIA Scoping Report	Requested inclusion of the following in the ESIA: • Process description; • Demolition; • Process waste management; • Any required remediation; • Assessment of the reliability and compliance of the remaining units; • Separate section on resource and energy efficiency; • Identification of sensitive receptors for air quality impacts; • [environmental baseline] surveys to include Ma'ameer Channel; • ESIA to address possible impacts on Ma'ameer Channel and mitigation; • Special consideration to be given to Ma'ameer Channel and development proposals to be co-ordinated with GDUP; • Comprehensive plan to monitor naturally occurring radioactive materials (NORM). (see **Appendix 5B**).
19/05/16	Submission of EA-4 Environmental Screening form for proposed temporary reclamation work in Ma'ameer Channel to allow construction of the new pipe bridge.	The BMP design has been changed so that the pipe crossing design will include no permanent reclamation, although temporary reclamation is expected to be required to facilitate construction.

Following submission of the ESIA to SCE, SCE will be expected to arrange a consultation meeting for a wide range of stakeholders comprising national and local government. EACS will be invited to make a presentation of the ESIA key findings to the stakeholders and will be expected to respond to stakeholders questions.

5.5.2 Bapco Consultations with SCE

Bapco have an on-going program of consultations and joint management meetings with the SCE with respect to strategic developments at the Refinery particularly in respect of control and reduction of emissions.

5.5.2.1 MTBE Containing Gasoline

Consultations have been on-going between Bapco and the SCE since 2011 regarding the import and storage of MTBE containing gasoline by Bapco and the import of pure MTBE for blending by Bapco to produce MTBE blended gasoline for the local demand. Available correspondence are included in **Appendix 5C** and summarized below.

SCE provided conditional approval for the import of MTBE containing gasoline in a letter issued on 6th October 2013 upon the MTBE assessment study prepared by Hart Energy - USA for Bapco and a presentation made on the same. Conditions focused on prevention and management of possible spills and occupational health protection measures. Bapco replied on 2nd October 2014 setting out their response to the conditions and requesting formally approval to proceed with importation of MTBE containing gasoline.

The Bapco letter of 2nd October 2014 also identified that Bapco was continuing to consider importation of neat MTBE and blending with gasoline to make MTBE blended gasoline at Sitra Tank Farm as part of the BMP project. The letter states that a separate environmental impact assessment will be provided by Bapco for this activity in accordance with SCE requirements set out in their letter of 6th October 2013. This undertaking is part of the BMP and is addressed as part of this ESIA.

5.5.2.2 Point Source Emissions from Older Refinery Units

Few process units, gas turbines and boilers at Bapco Refinery have emissions to air that do not fully comply with emission limit values given in current environmental standards. Even though these units were built prior to the introduction of the standards, Bapco has investigated the retrofitting of these units. Technical assessment studies have taken place and have shown that the capital cost of replacement of these units would be significant, but the improvement in local air quality will be marginal. This issue is related to the existing Refinery units and is part of an on-going consultation between Bapco and SCE.

5.6 Stakeholder Engagement with Local Government and Non-Governmental Organizations

A consultation session was held between Bapco, EACS and TPIT and invited local government, elected representatives, governmental advisors and NGOs. The invites are listed in **Table 5.3**.

Environment Arabia

Table 5.3 Invitees and Attendees for Bapco Consultation Session with Local Government and Non-Governmental Organizations

Name	Role / Organization
Ahmed Yusuf Al Ansari	Chairman of the Board, Southern Municipal Council
M. Dalal Kooheji	Southern Municipality
Hamad Alghatam	Southern Municipality
Essa Yousif	Southern Municipality
Mohamed Saeed	Southern Municipality
Eng. Zahwa Al Kuwari	Shura Council
Dr Mohamed Ali Hassan	Shura Council
Shubar Alwedaee	Bahrain Environment Society
Hassan Al Oud	Bahrain Environment Society
Abdulla Al-Kooheji	Bahrain Environment Society (BES)
Mr. Adel Al Asumi, Head Environment Committee - Council of Representatives, Mr Faisal bin Rashid Al Nuaimi and Hamad Juma, from the Southern Governorate Area were invited but could not attend.	

Minutes of the meeting and a copy of the presentation of the BMP are included as **Appendix 5D.**

5.7 Key Outcomes of Stakeholder Engagement

The stakeholder engagement has had direct impacts on the project design. The key outcomes from meetings to date with national government stakeholders were as follows:

1. Protection of archaeological sites – Following consultations with BACA, including a site visit, two archaeological sites to the south of the Refinery were identified to be at risk from the BMP development. The sites were located in an area to be used for labour camps. The location of the labour camps was revised to exclude the archaeological sites and it was agreed to fence off the archaeological sites to protect them. Further details are provided in **Section 13**.

2. Ma'ameer Channel Pipe Bridge – the pipe bridge across Ma'ameer Channel will require replacing as part of the BMP. The original design called for permanent reclamation within Ma'ameer Channel. During consultations GDUP indicated that such a design would be unlikely to obtain approval due to the permanent reclamation within the channel. In response the BMP design has been changed so that the pipe crossing design will include no permanent reclamation, although temporary reclamation is expected to be required to facilitate construction.

5.8 Next Steps

5.8.1 SCE

Once the ESIA reports are submitted to the SCE, they will have 60 working days to review the reports and provide any comments. As part of this process it is anticipated that the SCE will invite a range of stakeholders (which SCE selects) to attend a presentation of the BMP ESIA by Environment Arabia. The feedback from this meeting may be used by the SCE to advise their comments on the BMP ESIA.

6 AIR QUALITY

6.1 Introduction

This chapter of the ESIA describes the existing environment in relation to air quality and assesses the potential impacts of the construction and operation phases of the proposed Bapco Modernization Program (BMP).

Air quality around the current Bapco Refinery site is impacted by a number of air emission sources which include:

- Riffa Power Station;
- Alba Aluminium Works;
- The Bapco Refinery;
- Bahrain Oil and Gas Field;
- Other industrial activities;
- Road vehicle emissions;
- Construction work.

These activities are all contributors to local air pollution, which include emissions of sulphur dioxide (SO_2), nitrogen oxides (NO_X), carbon monoxide (CO), volatile organic compounds (VOC); hydrogen sulphide (H_2S) and fine particulates (usually expressed as the PM_{10} or $PM_{2.5}$ airborne fraction) . The ESIA has therefore evaluated available data to determine a representative baseline and quantified the impact of the implementation of the BMP upon sensitive receptors. This assessment also considered greenhouse gas (GHG) emissions from the existing Bapco refinery, and the addition of the BMP.

6.2 Legislation and Guidance

6.2.1 Air Quality Standards

Air quality standards are established to protect human health and the environment. This assessment was required to be conducted in line with the standards and principles provided by the International Finance Corporation (IFC, 2007). The 2007 IFC Guidelines provide assessment methods and significance criteria for international projects. Earlier versions of the EHS Guidelines (including Project Guidelines and other documents that were previously published in Part III of the Pollution Prevention and Abatement Handbook (PPAH), have been superseded. The guidance indicates that nationally adopted standards should be used, but in their absence, air quality guidelines recommended by the World Health Organisation (WHO, 2005) should be adopted. These principles were applied to define the assessment criteria for this study.

In Bahrain, national standards are laid down by the SCE. The current Bahrain National Standards[5] are summarised in **Table 6.1**. For comparison, international standards for SO_2, NO_2, CO and PM_{10} are also presented in the table.

[5] Ministerial Order No. 10 of 1999 with respect to Environmental Standards (air and water).

Table 6.1 Ambient Air Quality Standards and Guidelines

Pollutant	Averaging Period	Bahrain ($\mu g.m^{-3}$)	UK/EU ($\mu g.m^{-3}$)	WHO ($\mu g.m^{-3}$)
SO_2	10 minutes	-	-	500
	Hourly	350(1)	350(2)	-
	Daily	125	125(3)	20(4)
	annual	50	-	-
NO_2	Hourly	200	200(5)	200
	Daily	150	-	-
	Annual	40	40	40
CO	8-hourly	10 000	10 000	-
	Daily	-	-	-
	Annual	-	-	-
PM_{10}	Hourly	-	-	-
	Daily	340	50(6)	50
	Annual	-	40	20

Notes:

(1) Not to be exceeded more than twice in any 30-day period at a given location.
(2) Not to be exceeded more than 24 times a year.
(3) Not to be exceeded more than 3 times a year.
(4) WHO also proposed interim targets of $125\mu g.m^{-3}$, which is equal to the former WHO guidelines (WHO, 2000), and $50\mu g.m^{-3}$, which is viewed as a feasible and achievable goal that would lead to significant health improvements.
(5) Not to be exceeded more than 18 times a year.
(6) Not to be exceeded more than 35 times a year.

In accordance with the IFC guidance (IFC, 2007) this assessment was based on the Bahrain National Standards, where applicable, and WHO air quality Guidelines where standards are not available. The Bahrain national standards have been supplemented with the WHO air quality guideline of 20 $\mu g.m^{-3}$ for the assessment of annual mean PM_{10} concentrations.

The WHO air quality guideline values are presented as a set of interim targets followed by a guideline value. These stringent guideline values are provided to encourage continual improvement in areas where interim targets are routinely achievable. It is notable that the Bahrain National Standards relating to particulate matter are less stringent than those suggested by WHO. National standards are tailored to specific conditions in Bahrain, where achievement of stringent particulate criteria is unlikely due to naturally elevated background concentrations. Therefore, whilst the WHO annual standard for PM_{10} is used as a reference in accordance with the IFC Guidelines, its achievement across Bahrain is unlikely.

Prediction of the 10-minute average SO_2 concentrations for comparison with the short-term guideline is not possible using dispersion modelling. The WHO Air Quality Guidelines (WHO, 2005) state that:

> *"Because short-term SO_2 exposure depends very much on the nature of local sources and the prevailing meteorological conditions, it is not possible to apply a simple factor to this value in order to estimate*

> *corresponding guideline values over longer time periods, such as one hour."*

Dispersion modelling relies on hourly meteorological data to predict dispersion conditions and resulting pollutant concentrations and as such, comparison of hourly average values to the 10 minute guideline would not be valid.

6.2.2 Bahrain Environmental Standards

Ministerial Order No. 10 of 1999 with respect to Environmental Standards (air and water) sets out standards and their application as general provisions and for specific industries and emission sources.

Article 14 - covers hydrocarbon tank storage design and states that Volatile Organic Compounds (VOC) reservoirs, stores and tanks with a capacity over one thousand barrels (159 cubic meters) located within petroleum or petrochemical industrial establishments shall be equipped with a vapour seepage control system. The following vapour seepage control system methods may be used:

1. Vapour withdrawal system for storage units with a vapour pressure over 570mm of mercury.
2. Floating roof tank with double seals for storage units with a vapour pressure of between 78mm and 570mm of mercury.

Article 15 - Volatile organic compounds (VOC) emanating from operations involving petrol and petrochemical or any other industrial activities should be controlled using an appropriate cleaning methods and have a good maintenance system. Regular and continuous inspection of points from which vapour emission are expected must be undertaken to prevent any leaks.

Article 19 of Ministerial Order No. 10 of 1999 with respect to environmental standards (air and water) sets out smoke standards for emissions as:

> *"The amount of visible leaking emissions, (with exception to water vapour), from various industrial activities should be controlled so that maximum smoke density does not exceed 20% on the Ringleman Scale, with the exception of a three minute period during a continuous sixty (60) minute normal operation."*

6.2.3 Operational Emissions

Ministerial Order No 10 of 2006 with respect to air pollutant emissions requires certain industries to undertake on-line continuous emissions monitoring (CEM) and directly link the output to the SCE. This order is not currently complied with by industry in Bahrain, as the IT infrastructure to allow reception of the data has not been put in place. SCE have accepted that, given the very large number of air emission points at the Bapco Refinery, a predictive emissions monitoring system (PEMS) is a suitable measurement system for most point sources. PEMS is a model based solution, a calculation of emission rates based on the fuel type, gas flow rates, temperature and combustion or reaction stoichiometry. Bapco report their stack emissions to air to SCE regularly. The data submitted is a mixture of calculated data and stack measurements.

National emission limit values for the oil and gas industry are set within Ministerial Order No. 3 of 2001[6]. The guidance states that specific emission limit values (ELVs), as summarised in **Table 6.2** must not be breached.

Table 6.2 Air Emission Standards from Various Sources (extract relating only to Oil & Gas Industry) – Ministerial Order No. 3 of 2001

Industry	Source	Pollutant	Unit	Standard
Combustion Process[1]	Fuel combustion units, commercial, furnaces, industrial [1,2]	Particulate matter (PM)[3]	mg/m^3	50 for units with input energy > 50MW. 100 for units with input energy< 50MW (These values are for oil fired units)
		H_2S	PPM	600 – gas[4]
		SO_2	mg/m^3	500 – oil fired
		NO_X	mg/m^3	100 – gas fired
		NO_X	mg/m^3	150 – oil fired
		CO	mg/m^3	100
Petroleum Refining	General	H_2S	mg/m^3	150
		PM	mg/m^3	50
		CO	mg/m^3	100
		VOC	% recovery	95-100%
	Sulfur recovery units	SO_2	mg/m^3	150
	Other combustion units [5]	SO_2	mg/m^3	500
	Fluid Catalytic Cracking Unit (FCCU)	CO	ppm	500

[1] The emission standards of SO_2 and NO_X shall be applies to all combustion units in all industries. Emission standards of SO_2 and NO_X for sources other than combustion are also specified

[2] Combustion gases shall be dry, under temperature of 273K, pressure 101.3kPa and the oxygen content is adjusted to 15% V O_2/V total.

[3] The standard for particulate matter (PM) for other applications 50Mg/m^3

[4] If the fuel content of H_2S is more than this value then there requirement to use an equivalent SO_2 removal system to bring it to this value

[5] For units utilizing fuel other than natural gas

[6] Ministerial Order No. 3 of 2001 amending certain Tables attached to Ministerial Order No. 10 of 1999 with respect to environmental standards (air and water) as amended by Ministerial Order No. 2 of 2001

6.2.4 Green House Gas Emissions

Bahrain ratified the Kyoto Protocol in 2006 and is considered in Resolution Number 51 of 2007 'Establishing the Joint Committee on Climate Change', and Resolution Number 57 of 2015 'Amending the first article of Resolution No. 51 of 2007 Establishing the Joint Committee on Climate Change'. The Kyoto Protocol commits State Parties to reduce GHGs through a series of emissions targets and GHG reduction measures.

An International benchmark for comparison of GHG emissions is the International Finance Corporation Performance Standard 3, *'Resource Efficiency and Pollution Prevention* (IFC, 2012). The Standard provides a reporting threshold of 25,000 tonnes of CO_2e equivalent per year, above which organisations should formally report annual GHG emissions. The Equator Principles (Equator Principles, 2013) go further and require public reporting where GHG emissions exceed 100,000 tonnes per annum.

6.3 Baseline Air Quality

There is no current state funded air pollution monitoring in the vicinity of the Bapco Refinery. Previously, the government operated an air quality monitoring network which included an automatic monitoring station in the Central Governorate. This network was discontinued in late 2012.

In preparation of the ESIA for the BMP, an air quality monitoring station (AQMS) was established in January 2016, approximately 2km north-west of the refinery. The AQMS was established to provide continuous ambient measurements of air pollutant concentrations to inform the baseline air quality assessment.

The AQMS was located at the northern extent of the Bahrain National Transportation Yard, Riffa, Bahrain. This location is in an area representative of background air quality upwind of the Bapco refinery to characterise conditions at residential receptor locations. Due to the siting of the AQMS near to the transportation yard, there is potential that the location could be affected by vehicle emissions during peak activity times, (approximately 8am). Although no specific peaks in pollutant concentrations were observed during a screening of the background data, any impacts of vehicle emissions from the transport yard would overstate background concentrations at locations distanced from the local pollution source. This however represents a conservative, upper end, position which may increase the predicted environmental concentrations at receptor locations.

Results for the monitoring station are summarised in **Table 6.3** and relate to pollutant measurements taken between 25th January and 27th April 2016. The information is summarised to show monthly data and full dataset averages for sulphur dioxide (SO_2), nitrogen dioxide (NO_2), carbon monoxide (CO) particulate matter (PM_{10}), Hydrogen Sulphide (H_2S) and non-methane volatile organic compounds (NMVOC).

Evaluation of the AQMS data and comparison to relevant air quality standards indicated that:

- SO_2 – mean concentrations, daily averages and hourly maxima were below the Bahrain National Standards.

- NO_2 - mean concentrations, daily averages and hourly maxima were below the Bahrain National Standards.
- CO – the maximum 8 hour rolling mean was well below the Bahrain National Standard
- PM_{10} – daily averages were below the Bahrain National Standard. The cumulative hourly average value over the monitoring period, used to represent annual average conditions, was above the WHO annual mean air quality guideline value (but see previous comments on the applicability of this guideline).
- H_2S - hourly maxima were well below the WHO standard of 150 µg.m^{-3} with a maximum hourly value of 17.1 µg.m^{-3} being recorded.
- NMVOC - hourly maxima were recorded as less than 12.1ppm. There is no relevant national, WHO or EU ambient standard for non-speciated VOCs.

Hourly plots for concentrations of SO_2, NO_2, CO, PM_{10}, H_2S and NMVOC are provided as **Figures 6.1 - 6.6**.

Table 6.3 Air Quality Monitoring Results, Riffa, 2016

Pollutant	Averaging Period	Pollutant Concentration			
		25/01/2016 to 25/02/2016	25/02/2016 to 25/03/2016	25/03/2016 to 27/04/2016	Full Dataset
SO_2	Maximum hourly value (µg.m^{-3})	226.0	234.9	179.9	234.9
	24 hour maximum value (µg.m^{-3})	89.4	40.0	45.4	89.4
	Average (µg.m^{-3})	25.5	14.7	16.6	18.9
NO_2	Maximum hourly value (µg.m^{-3})	83.8	54.1	60.4	83.8
	24 hour maximum value (µg.m^{-3})	26.2	20.9	22.7	26.2
	Average (µg.m^{-3})	12.3	13.0	14.0	13.1
CO	Maximum hourly value (mg.m^{-3})	3.9	2.4	6.3	6.3
	Maximum 8 hourly value -rolling mean (mg.m^{-3})	1.9	2.0	5.5	5.5
	Average (mg.m^{-3})	0.4	0.8	1.2	0.8
PM_{10}	Maximum hourly value (µg.m^{-3})	476.7	1671.2	350.1	1671.2
	24 hour maximum value (µg.m^{-3})	138.3	295.5	131.0	295.5
	Average (µg.m^{-3})	113.0	131.6	116.5	120.0
H_2S	Maximum Hourly value (µg.m^{-3})	9.6	17.1	14.6	17.1
NMVOC*	Maximum hourly value (ppm)	5.2	12.1	5.9	12.1

Figure 6.1 AQMS Monitoring data – SO_2

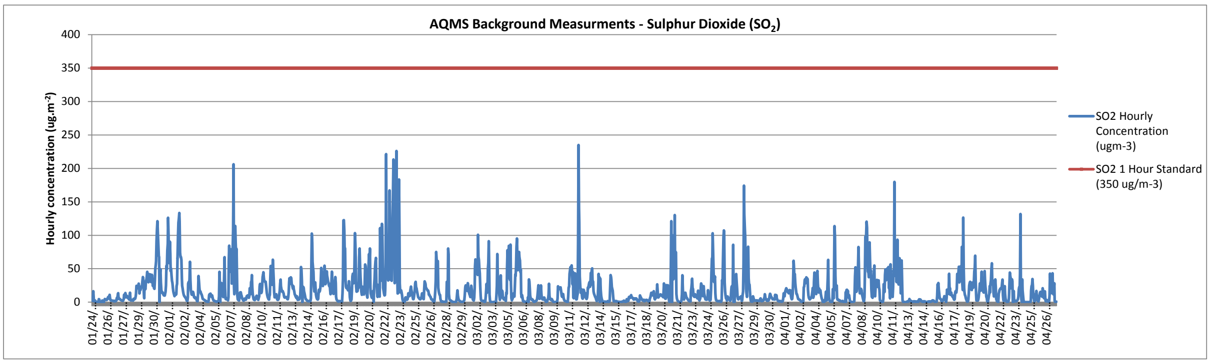


Figure 6.2 AQMS Monitoring data – NO_2

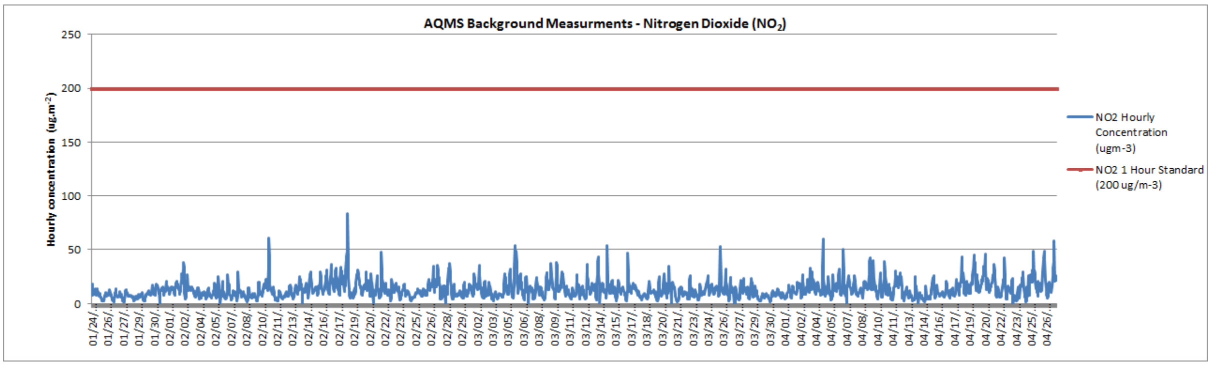


Figure 6.3 AQMS Monitoring data – CO

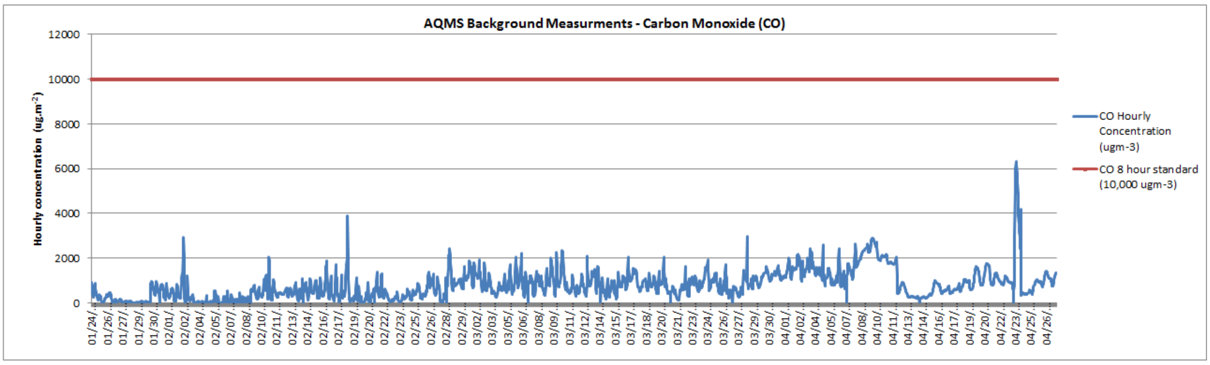


Figure 6.4 AQMS Monitoring data – PM_{10}

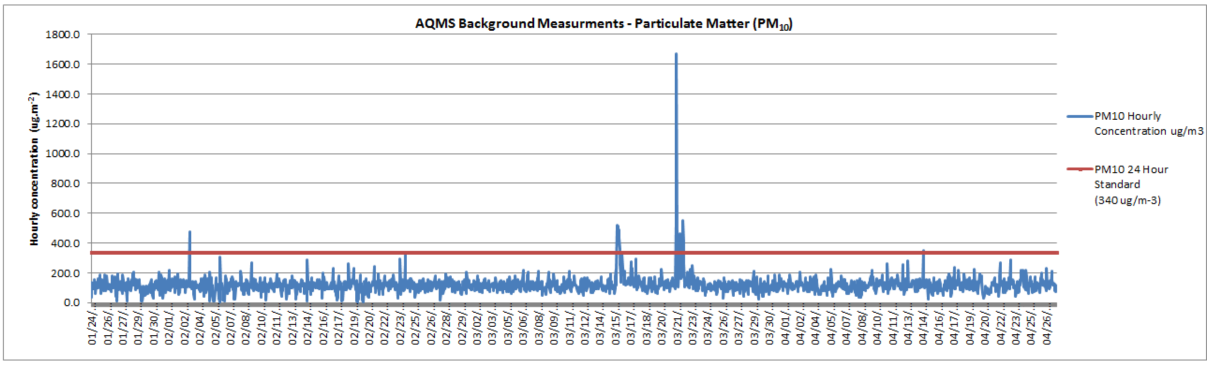


Figure 6.5 AQMS Monitoring data – H_2S

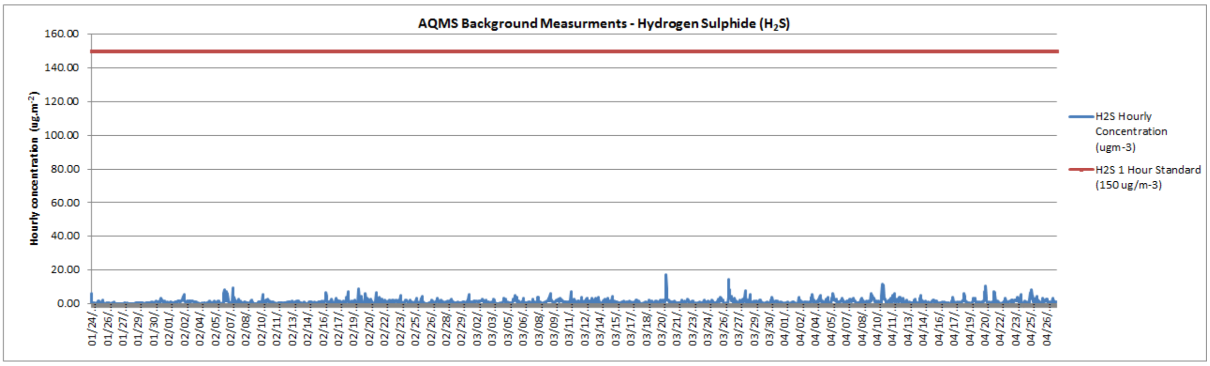
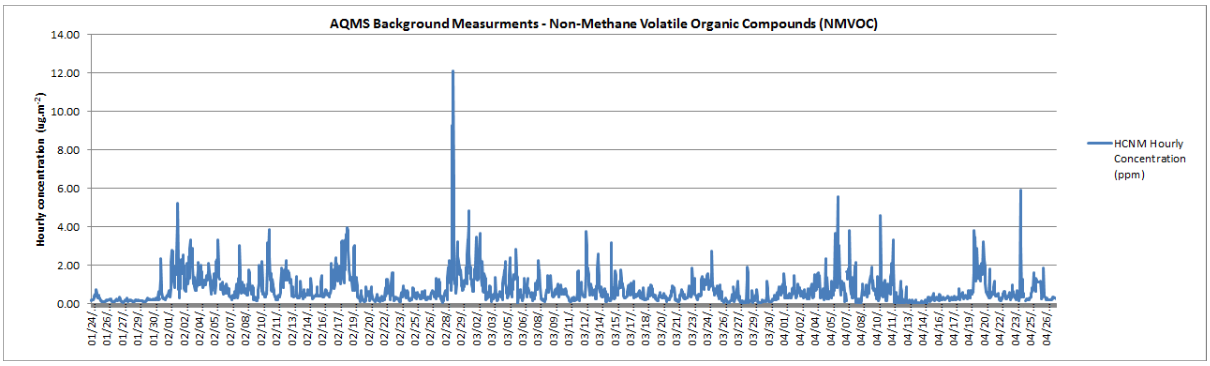


Figure 6.6 AQMS Monitoring data – NMVOC



Diffusion tube monitoring was undertaken at seven locations in the vicinity of the Refinery. This included co-location of a triplicate set of tubes with the AQMS. The following tubes were used:

- NO_2 and SO_2 combined tubes;
- H_2S
- VOCs (analysed for the top ten component VOC species concentration measured.)

A trip blank was also used for each set of tubes. The diffusion tube monitoring locations are shown in **Figure 6.4**. The AQMS is located at AQ3.

A supplementary air quality monitoring report will be submitted following submission of the main ESIA. The supplementary report will include six months of monitoring data from the continuing diffusion tube survey.

6.3.1 Emissions Inventory

To document the changes to the plant and net emissions to air, an emissions inventory was compiled for the refinery site. The inventory includes all stack locations; stack heights; emission rates; emission temperatures and pollutant concentrations. The inventory is based upon both measured and calculated data.

The inventory represents releases from the existing plant and forms part of Bapco's reporting of emissions to the SCE. As the BMP is implemented, the emissions inventory will be updated by removing decommissioned processes and providing emission data for new sources as they are incorporated into the site. The emission inventory for both the existing scenario and BMP sources are provided in **Appendix 6A**.

The emissions inventory indicated that total pollutant emissions from the site for the baseline and BMP scenarios would be:

- SO_2
  - Baseline Scenario – 257.9 $g.s^{-1}$
  - BMP Scenario – 112.0 $g.s^{-1}$
- NO_X
  - Baseline Scenario – 300.4 $g.s^{-1}$
  - BMP Scenario – 289.7 $g.s^{-1}$
- PM_{10}
  - Baseline Scenario – 64.6 $g.s^{-1}$
  - BMP Scenario – 64.4 $g.s^{-1}$
- CO
  - Baseline Scenario – 67.9 $g.s^{-1}$
  - BMP Scenario – 100.34 $g.s^{-1}$

Changes in total emission rates cannot be used to infer either increases or reductions in pollutant concentrations at receptor locations. Ground level off-site impacts of a range of air pollutant releases are determined by the source emission rate, but also by a number of other parameters including the release height and conditions, local building and structure wake and downwash effects, the wider terrain, atmospheric interactions and meteorological dispersion conditions. Whilst a reduction in source emission rate would be expected to give rise to lower ambient pollutant concentrations, the relationship is complex, short-term and annual average impacts may differ, and the location of impact may also change.

Title: Air Quality Monitoring Locations		Client: Bapco Technip
Project: Bapco Modernization Program		
Date: September 2015	Figure No.: 6.4	Consultant: Environment Arabia
Datum: WGS 84 - UTM 39 N	Scale: 1:30,000 (A4)	

CN:\Bapco Modernisation Plan\mxd\air quality.mxd

6.4 Assessment Methodology

6.4.1 Baseline Air Quality

The assessment used the AQMS data to determine the baseline air quality conditions for the area. The three month dataset has been used to represent annual conditions rather than historical monitoring data which may not represent current baseline conditions.

Detailed assessment of short-term effects is complex as the maximum process contribution and maximum background concentration may be separated both temporally and spatially, so that the addition of the two 'worst case' concentrations together may not represent a likely event. As short-term pollutant concentrations vary (see **Figures 6.1** to **6.6** which demonstrate this), the assessment used the conservative assumption that short term background concentrations should be represented by a value equal to twice the long term mean. This approach is applied in the permitting of industrial processes and is a conservative way to consider fluctuating process emissions, set against varying dispersion conditions and a varying background.

The AQMS site was selected as an 'urban background' location, representative of people's exposure to a range of air pollution sources from road traffic and industry. The location is away from the local major road network, and upwind of the existing refinery, and the measured data therefore reflect local and more distant sources, following the dispersion and dilution of these emissions.

The data were assessed and there is no evidence of short term peaks in measured pollutant concentrations associated with vehicle activity in the proximate transport yard. The long term measured values will incorporate a contribution from existing Bapco emissions, along with components of other industrial and road transport releases, but at a location not directly subject to such emissions. Thus the data are a reasonably conservative representation of baseline air quality conditions in the area.

6.4.2 Construction Phase Assessment

An assessment of potential impacts associated with the construction phase was undertaken using a risk-based approach, based on screening criteria and consideration of the scale of likely activities and the proximity to sensitive receptors. In the absence of Bahraini national technical guidance on the assessment of construction effects on air quality, the principles and main procedures laid down in guidance provided by the UK Institute for Air Quality Management (IAQM, 2014) were applied. A summary of the assessment process is provided below:

Construction phase assessment steps:

1) Screen the need for a more detailed assessment;
2) Separately for demolition, earthworks, construction and trackout:
    A. determine potential dust emission magnitude;
    B. determine sensitivity of the area; and
    C. establish the risk of dust impacts.
3) Determine site specific mitigation; and

4) Examine the residual effects to determine whether or not additional mitigation is required.

It should be noted that trackout is defined as the transport of dust and dirt from the construction site onto the public road network.

6.4.3 Operational Phase Assessment

Pollutant emissions from the Bapco Refinery were modelled using the AERMOD atmospheric dispersion model, utilising the most up to date 15181 AERMOD executable. AERMOD is an advanced dispersion model based on the Gaussian theory of plume dispersion, developed by the United States Environmental Protection Agency (US EPA). It is widely used across the world for regulatory and assessment purposes. Atmospheric dispersion is determined by input data (stack and pollutant release parameters, the terrain, hourly sequential meteorological data and building dimensions) to calculate ground level pollutant concentrations across a selected receptor grid and discrete receptor points.

6.4.4 GHG Assessment

A GHG assessment was carried out which considered emissions from gas and electricity consumption at the refinery post the installation of the BMP.

The GHG assessment was undertaken in accordance with the global standard outlined in the GHG Protocol (WRI, 2016), which defines three groups of GHG emissions that arise from a development:

- Scope 1 emissions are direct GHG emissions arising from directly associated activities at the refinery, such as burning process gases to fire heaters and equipment;
- Scope 2 emissions account for GHG emissions from the consumption of purchased electricity and gas at the refinery; and
- Scope 3 emissions are indirect emissions arising from upstream and downstream activities products made by the refinery.

The GHG Protocol recommends that Scope 1 and Scope 2 emissions are accounted in a GHG emissions assessment of a development project. Therefore, this high level assessment considered Scope 1 emissions, from the consumption of process gas and electricity generated within the refinery, and Scope 2 emissions, resulting from purchased electricity used in the refinery.

The boundary for the GHG emissions assessment was designated to be within the site boundary, where the oil refining takes place and where purchased electricity is consumed.

Emission factors used to predict GHGs from the process were all approved and certified within the GHG Protocol. Emission factors were provided in carbon dioxide equivalents (CO_2e) therefore were considered to be representative of all GHGs emitted from the refinery, including methane (CH_4) and nitrous oxide (N_2O). Emission factors were obtained from the International Energy Agency (IEA, 2012), and the UK Department for Environment, Food and Rural Affairs (Defra, 2016), who produce an annual database of emission factors that can be used to report GHG emissions. Emission factors used in the assessment are provided in **Table 6.4**.

Table 6.4 Emission Factors Used in the GHG Assessment

Activity	Emission factor	Units
Consumption of Generated Process Gas	0.02470	kg/kwh CO_2e
Consumption of Electricity	0.652	kg/kwh CO_2e

There were a number of assumptions used in the assessment, these are detailed below:

- Data for consumption of generated process gas were provided in units of mega joules. These were converted to units of kWh using a conversion factor of 0.27778;
- It was assumed that all of the generated process gas was consumed within the refinery;
- It was assumed that the refinery will process 360,000 barrels per day in the post-BMP scenario;
- A conversion factor of 7.14 was used to convert barrels of processed fuel oil into units of metric tonnes; and
- Due to the unavailability of data, the impact of re-using waste gas and oil produced by the refinery was not captured within the GHG emissions assessment.

6.4.5 Metrological Data

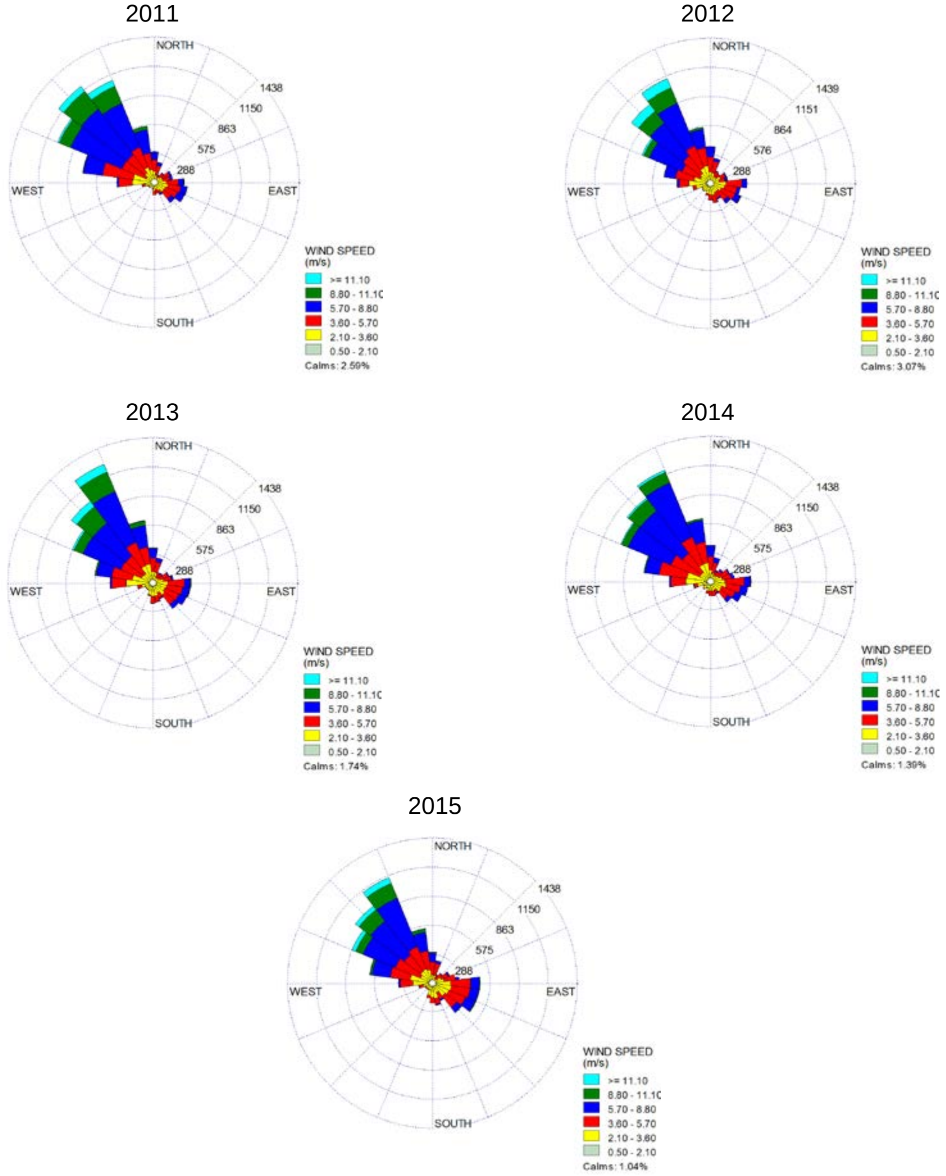
Five years (2011 – 2015) of hourly sequential meteorological data from the Bahrain International Airport meteorological recording station were used in the AERMOD model. This metrological recording station was the closest (approximately 16km to the north) and most representative recording station for the study area. Wind roses for 2011 - 2015 are provided in **Figure 6.5**. Evaluation of the wind roses indicated a predominant north westerly wind direction across the five year period.

The meteorological data were processed to make their interaction with the land surface representative of the surrounding area. The study area was classified with the following land use sectors and classifications:

Table 6.5 Modelled Land Use Classifications

Sector	Land Use Classification	Condition	Albedo	Bowen ratio	Surface Roughness
0-200^{O}	Urban/industrial	Dry	0.2075	3	1
200-280^{O}	Desert	Dry	0.3275	7.75	0.1
280-360^{O}	Urban/industrial	Dry	0.2075	3	1

Figure 6.5 Annual Wind Roses – Bahrain 2011-2015



6.4.6 Terrain

To represent the influence of terrain elevations in the dispersion of pollutants a digital elevation file was used in the AERMOD model. For both the receptors and grid points the recommended Lakes Inverse Distance interpolation was used. This function interpolates the neighbouring points using the inverse distance to obtain the elevation at the desired point. The assessment has used the SRTM1 global topographical survey data which is reported at approximately 30m intervals.

Environment Arabia

6.4.7 Buildings

The assessment has incorporated buildings into the dispersion model to predict the impact of their interaction with plume dispersion. The Building Profile Input Programme (BPIP) algorithm was used to calculate building downwash parameters within AERMOD.

The assessment has considered any building which is in excess of 10m in height and in the immediate vicinity of an emission source. The BPIP model considers the plume effects of stacks within a defined Structure Influence Zone (SIZ) which is based on the dimensions of the building and the proximity to the emission source.

6.4.8 Conversion of NO_X to NO_2

This assessment has used the UK Environment Agency (EA, 2011) approach to the conversion rates for NO_X to NO_2. The UK EA has adopted the following approach.

- 50% of the modelled values should be used for short-term concentrations; and
- 100% of the modelled values should be used long term average concentrations.

In accordance with these recommendations, the short term (1 hour) and long term (annual mean) concentrations of NO_2 were derived from the predicted NO_X concentrations using the following approach: 50% of NOx to NO_2 for short term and 100% of NO_X to NO_2 for long term average concentrations.

6.4.9 Assessment Scenarios

The assessment considered the following scenarios;

- Scenario One: Existing Baseline - including emissions from the existing Bapco Refinery; and
- Scenario Two: Future Baseline - after full implementation of the BMP.

The scenarios considered concentrations of SO_2, NO_2, PM_{10} and CO at selected receptor locations in the local area. The assessment has been conducted based on the 'normal' operating conditions for both the existing and BMP scenarios. Emissions from emergency flares have not been explicitly considered in the modelling as they are only used infrequently in emergency situations. The flares will be designed to have dispersion properties that minimise impacts at sensitive receptor locations. During flaring events, the emissions would be emitted from a height nearly double that of the highest BMP source stack (preliminary design is 160m) and at an increased temperature which would improve pollutant dispersion.

The dispersion modelling assessment has not quantified the off-site effects of fugitive emissions of H_2S and VOCs. Fugitive and evaporative emissions from the existing activities are subject to ongoing controls and management and low level releases will predominantly affect only the immediate locality within the refinery site. . Minimisation of fugitive emissions will be part of the design philosophy of the new BMP storage facilities and process units, which will use best practice technology and controls to prevent losses.

The assessment scenarios used current baseline air pollution conditions to calculate the predicted environmental concentration (PEC). No correction was made to estimate changes in air quality between the base year and date of completion of the BMP.

The assessment has not modelled emissions from any other local air pollution source as background monitoring data were assumed to reflect other industrial pollution sources in the measurements. Committed and proposed developments, including expansion of the ALBA power station, will be built and operated in the vicinity of the Bapco Refinery. These future sources have not been included in this assessment but may increase pollutant concentrations at receptor locations. This assessment has been designed to identify whether the specific process contribution of the Bapco Refinery at receptor locations would change by implementation of the BMP.

6.4.10 Calculation of Emission Rates

The emission rates used in this assessment were based upon relevant monitored or calculated pollutant data specific to each individual source.

Emissions from the existing facility were obtained from a review of calculated and measured air pollution concentration data. The data provided by Bapco, includes calculated and measured emissions in both 2014 and 2015 for NO_X SO_2 and CO. The assessment used the highest result from these four datasets to represent emissions from the facility. The monitoring programme was comprehensive; however where gaps were observed, relevant vendor specification pollutant concentrations were used to represent the individual sources. Routine measurement of PM_{10} is not undertaken due to gas phase fuels achieving efficient combustion and low particulate releases, and as such a typical vendor specification of $30mg/m^3$ was assumed to represent emissions from all sources.

Emissions from the proposed BMP sources were calculated from information provided by the project's engineering design team, Technip. For each of the new BMP sources, calculated emissions were either based upon the process design of new sources or by replication of identical sources already implemented on the refinery. Relevant vendor specification pollutant concentrations were used where specific pollutant parameters were not available. The source release data are provided in the emissions inventory, detailed at **Appendix 6A**.

The assessment used the following vendor specification pollutant concentrations for all sources under normalised conditions (reference values for dry air at 0^oC and 15% O_2).

- NO_X – 100 $mg.m^{-3}$
- SO_2 – 150 $mg.m^{-3}$
- CO – 100 $mg.m^{-3}$
- PM_{10} – 30 $mg.m^{-3}$

These values have been used for all sources where calculated or measured data was not available. The vendor specification pollutant concentrations used in the assessment were either equal to, or below those stipulated within Ministerial Order No. 3 of 2001[8]. Use of the vendor specification pollutant concentrations was largely limited to the prediction of emissions of PM_{10} in the baseline scenario and PM_{10} and CO for proposed BMP sources.

The assessment considered 58 individual process sources in the baseline scenario. The BMP involves the decommissioning of 13 currently emitting sources and replacement with 15 new processes.

6.4.11 Selection of Receptor Locations

Sensitive receptor locations were identified within the study area for consideration in the assessment. Predicted changes in NO_2, SO_2, CO and PM_{10} concentrations as a result of emissions from the development were calculated at these locations.

Selection of receptor locations was based upon conventional air quality practice which indicates that air quality objectives apply in positions of outdoor public exposure at locations where a member of the public is reasonably expected to be present for the appropriate averaging time. The sensitive receptor locations were selected based on their proximity to the Bapco Refinery. 23 receptors were selected to represent both worst case and typical conditions in the residential areas around the Bapco Refinery, and so included residential locations in closest proximity to the refinery. One modelled receptor location was the position of the AQMS. The selected receptor locations are detailed in **Table 6.6** and shown in **Figure 6.6**.

The model inputs also included two Cartesian receptor grids to allow production of contour plots. These included a large scale 25 x 25 km grid, using a resolution of 1,000m, with an embedded local scale 8 x 8 km grid, at a resolution of 100m.

Table 6.6 Selected Sensitive Receptor Locations

Reference	Area	Coordinates	
		x (m)	y (m)
R1	Askar	461500	2882000
R2	West Riffa	454000	2889500
R3	Nuwaidrat	460000	2890800
R4	Al Akr	461000	2891800
R5	Awali - 1	455000	2885500
R6	Ma'ameer	461500	2890800
R7	East Riffa	457000	2889200
R8	Sanad	458300	2892300
R9	Manama	458000	2900700
R10	Zallaq	448500	2881600
R11	Askar	462700	2880100
R12	Ras Abu Jarjur	461200	2883700

[8] Ministerial Order No. 3 of 2001 amending certain Tables attached to Ministerial Order No. 10 of 1999 with respect to environmental standards (air and water) as amended by Ministerial Order No. 2 of 2001

Reference	Area	Coordinates	
		x (m)	y (m)
R13	AQMS	458737	2889413
R14	East Riffa (2)	458605	2889328
R15	East Riffa (3)	458509	2889213
R16	East Riffa (4)	458032	2888776
R17	Awali (2)	457047	2887352
R18	Awali (3)	457104	2886141
R19	Um Albaidh	463635	2888010
R20	Um Albaidh (2)	463649	2888742
R21	Ma’ameer (2)	461454	2890134
R22	Nuwaidrat (2)	460055	2890385
R23	Nuwaidrat (3)	459562	2890188

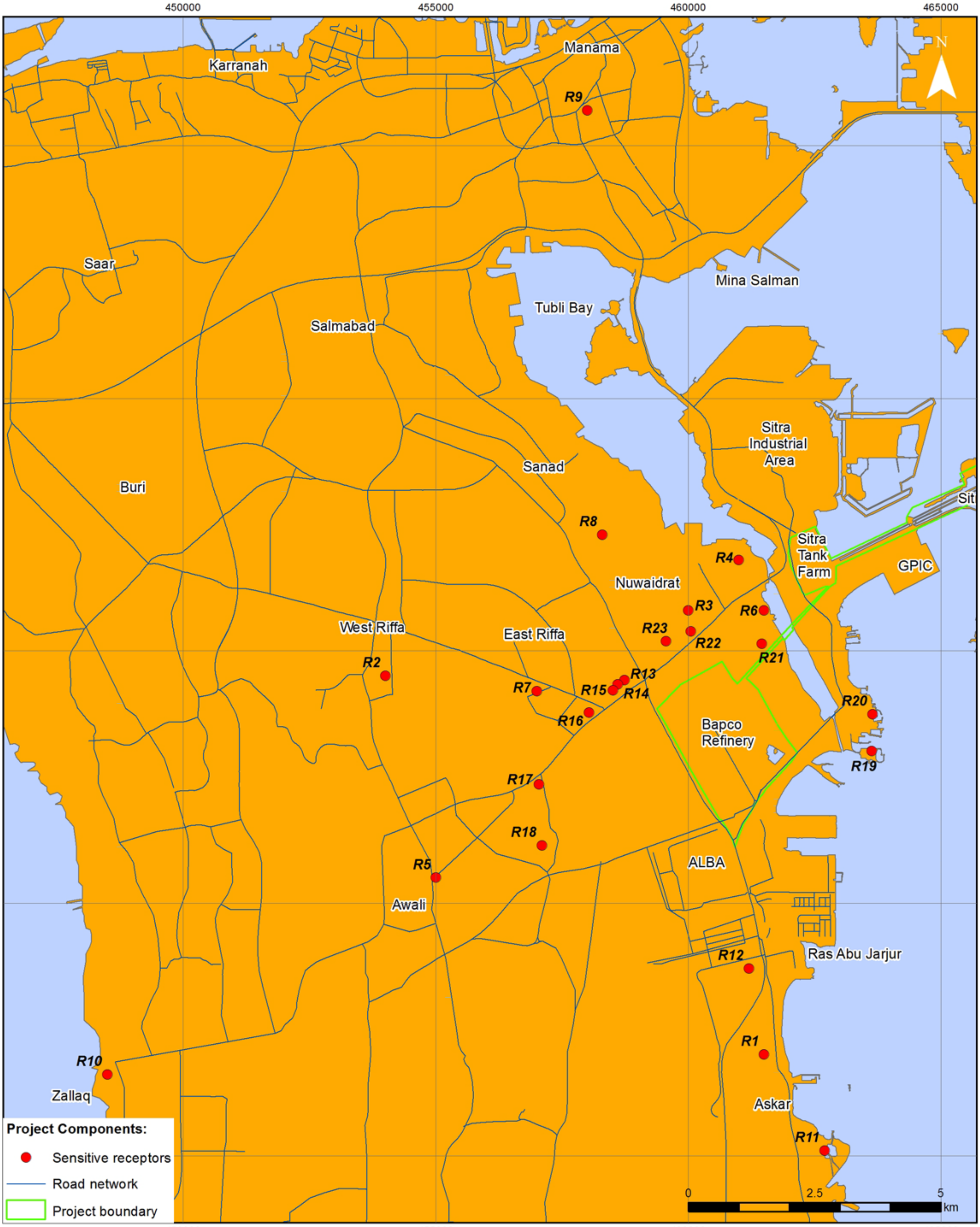
6.4.12 Assessment Significance Criteria

The assessment used the screening criteria provided by the IFC (IFC, 2007) which were as follows:

- *Emissions do not result in pollutant concentrations that reach or exceed relevant ambient quality guidelines and standards by applying national legislated standards, or in their absence, the current WHO Air Quality Guidelines or other internationally recognized sources; and*
- *Emissions do not contribute a significant portion to the attainment of relevant ambient air quality guidelines or standards. As a general rule, this Guideline suggests 25 percent of the applicable air quality standards to allow additional, future sustainable development in the same airshed.*

Where relevant standards are predicted to be met, the assessment has considered that air quality impacts are not significant and meet the IFC requirements. These standards would be applied to all emission sources after implementation of the BMP, which would include retained process sources. The significance of air quality impacts was classified as beneficial where an improvement in air pollutant concentrations at the worst affected receptors was predicted.

In describing air quality at receptor locations, the assessment has used the terms Process Contribution (PC), the modelled value as a result of Bapco emissions, and the Predicted Environmental Concentration (PEC), which is the PC added to the local background pollutant concentration. The impact assessment therefore considers both the PC, that is, the additional contribution or reduction in receptor pollutant concentrations as a consequence of the BMP, and also PEC, the total resulting concentration at receptor locations.



Title: **Selected Receptor Locations**		Client: Bapco Technip
Project: Bapco Modernization Program		
Date: June 2016	Figure No.: 6.6	Consultant: Environment Arabia
Datum: WGS 84 - UTM 39N	Scale: 1:1,000,000 (A4)	

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Environment Arabia

6.5 Impact Assessment

6.5.1 Baseline Air Quality Conditions

The AERMOD dispersion model was used to predict pollutant contributions at receptor locations from the existing Bapco facility. The assessment predicted concentrations of NO_2, SO_2, CO and PM_{10} for comparison against the relevant air quality standards. Summary results are provided as **Table 6.7** with the maximum predicted baseline concentrations, at all receptor locations, detailed in **Tables 6.8 – 6.10**.

For the baseline scenario, the modelled environmental concentration (PEC) at all receptors was predicted to be below the Bahrain National Standards. The assessment however did predict that the WHO annual mean PM_{10} air quality guidance level of 20µg.m^{-3} was breached at all locations (although the relevance of the application of this stringent standard is discussed above). This was caused by elevated background PM_{10} concentrations, 120.0 µg.m^{-3} as defined by the AQMS monitoring data, as opposed to the process contribution (PC) of the Bapco Refinery, which was predicted to be no more than 1.7 µg.m^{-3} (or 8.5% of the air quality standard).

Table 6.7 Baseline Scenario – Modelled Concentrations at Worst Case Receptor

Pollutant	Averaging Period	PC µg.m^{-3}	National standard µg.m^{-3}	WHO Guideline µg.m^{-3}	% of Std or Guideline
SO_2	Maximum hourly value	99.2	350	-	28.3%
	24 hour maximum value	52.8	125	-	42.3%
	Annual Average	5.0	50	-	10.0%
NO_2	Maximum hourly value	68.1	200	-	34.1%
	24 hour maximum value	36.0	150	-	24.0%
	Annual Average	7.0	40	-	17.5%
CO	Maximum 8 hourly value -rolling mean	51.4	10,000	-	0.5%
PM_{10}	24 hour maximum value	15.9	340	-	4.7%
	Annual Average	1.7	-	20	8.5%

Table 6.8 Baseline Scenario – Modelled Concentrations of SO_2

Receptor	Pollutant Concentration – $\mu g.m^{-3}$					
	Annual Mean		Maximum 24 Hour Mean		Maximum 1 Hour Value	
	AQS – 50		AQS – 125		AQS - 350	
	PC	PEC	PC	PEC	PC	PEC
R1	1.2	20.1	14.3	52.1	43.9	81.7
R2	1.1	20.0	12.0	49.8	42.0	79.8
R3	1.9	20.8	28.2	66.0	85.4	123.2
R4	1.2	20.1	18.7	56.5	65.1	102.9
R5	0.5	19.4	12.3	50.1	42.6	80.4
R6	1.1	20.0	15.0	52.8	82.5	120.3
R7	2.2	21.1	22.3	60.1	61.5	99.3
R8	1.3	20.2	17.1	54.9	51.1	88.9
R9	0.5	19.4	8.6	46.4	35.0	72.8
R10	0.3	19.2	6.7	44.5	33.2	71.0
R11	1.1	20.0	11.3	49.1	38.0	75.8
R12	1.8	20.7	22.7	60.5	55.5	93.3
R13 - AQMS	5.0	23.9	52.8	90.6	96.6	134.4
R14	4.7	23.6	47.5	85.3	94.0	131.8
R15	4.5	23.4	46.1	83.9	92.7	130.5
R16	3.3	22.2	29.3	67.1	80.9	118.7
R17	1.4	20.3	17.2	55.0	61.5	99.3
R18	0.9	19.8	17.0	54.8	57.4	95.2
R19	3.5	22.4	22.4	60.2	83.1	120.9
R20	1.0	19.9	12.1	49.9	73.8	111.6
R21	1.2	20.1	16.5	54.3	94.5	132.3
R22	2.3	21.2	33.8	71.6	99.2	137.0
R23	2.8	21.7	34.0	71.8	97.3	135.1

Table 6.9 Baseline Scenario – Modelled Concentrations of NO_2

Receptor	Pollutant Concentration – µg.m^{-3}					
	Annual Mean		Maximum 24 Hour Mean		Maximum 1 Hour Value	
	AQS – 40		AQS - 150		AQS - 200	
	PC	PEC	PC	PEC	PC	PEC
R1	1.7	14.8	8.5	34.7	43.7	69.9
R2	1.5	14.6	8.2	34.4	39.1	65.3
R3	2.8	15.9	20.9	47.1	61.0	87.2
R4	1.9	15.0	14.9	41.1	49.8	76.0
R5	0.7	13.8	9.4	35.6	39.4	65.6
R6	1.6	14.7	10.8	37.0	56.9	83.1
R7	3.1	16.2	15.2	41.4	46.9	73.1
R8	1.9	15.0	14.2	40.4	45.2	71.4
R9	0.7	13.8	7.2	33.4	35.6	61.8
R10	0.4	13.5	5.6	31.8	33.7	59.9
R11	1.5	14.6	8.1	34.3	37.9	64.1
R12	2.5	15.6	13.9	40.1	47.8	74.0
R13 - AQMS	7.0	20.1	36.0	62.2	64.2	90.4
R14	6.6	19.7	33.3	59.5	62.6	88.8
R15	6.2	19.3	31.1	57.3	61.5	87.7
R16	4.4	17.5	20.5	46.7	55.5	81.7
R17	1.8	14.9	14.7	40.9	46.6	72.8
R18	1.1	14.2	12.9	39.1	45.3	71.5
R19	4.8	17.9	16.5	42.7	58.6	84.8
R20	1.4	14.5	9.0	35.2	55.0	81.2
R21	1.6	14.7	10.3	36.5	63.1	89.3
R22	3.2	16.3	24.7	50.9	68.1	94.3
R23	3.8	16.9	24.5	50.7	65.9	92.1

Table 6.10 Baseline Scenario – Modelled Concentrations of CO and PM_{10}

Receptor	Pollutant Concentration – $\mu g.m^{-3}$					
	CO Maximum 8 Hour Rolling Mean		PM_{10} - Annual Mean		PM_{10} – Maximum 24 Hour Mean	
	AQS – 10,000		AQS - 20		AQS – 340	
	PC	PEC	PC	PEC	PC	PEC
R1	14.7	1614.7	0.4	120.4	3.7	243.8
R2	17.4	1617.4	0.3	120.3	3.7	243.9
R3	46.1	1646.1	0.7	120.7	10.5	250.5
R4	31.8	1631.8	0.5	120.5	6.9	246.9
R5	20.0	1620.0	0.2	120.2	4.3	244.3
R6	30.0	1630.0	0.4	120.4	5.0	245.6
R7	27.4	1627.4	0.7	120.7	6.5	246.9
R8	27.1	1627.1	0.5	120.5	6.2	246.2
R9	12.8	1612.8	0.2	120.2	2.8	243.4
R10	11.3	1611.3	0.1	120.1	2.4	242.4
R11	17.2	1617.2	0.3	120.3	3.5	243.5
R12	21.3	1621.3	0.6	120.6	5.9	246.1
R13 - AQMS	43.0	1643.0	1.7	121.7	15.9	255.9
R14	42.4	1642.4	1.6	121.6	14.6	254.6
R15	41.4	1641.4	1.5	121.5	14.5	254.5
R16	33.4	1633.4	1.0	121.0	9.9	249.9
R17	22.0	1622.0	0.4	120.4	4.1	247.4
R18	23.6	1623.6	0.3	120.3	5.7	245.7
R19	36.8	1636.8	1.1	121.2	7.9	247.9
R20	38.8	1638.8	0.4	120.4	4.9	244.9
R21	28.3	1628.3	0.4	120.4	5.0	245.7
R22	51.4	1651.4	0.9	120.9	12.6	252.6
R23	47.1	1647.1	1.0	121.0	11.7	251.7

Environment Arabia

6.5.1.1 Construction Phase – Construction Dust Assessment

Construction activities required for the BMP have the potential to increase dust levels near to the site and along principal haul routes used by construction vehicles.

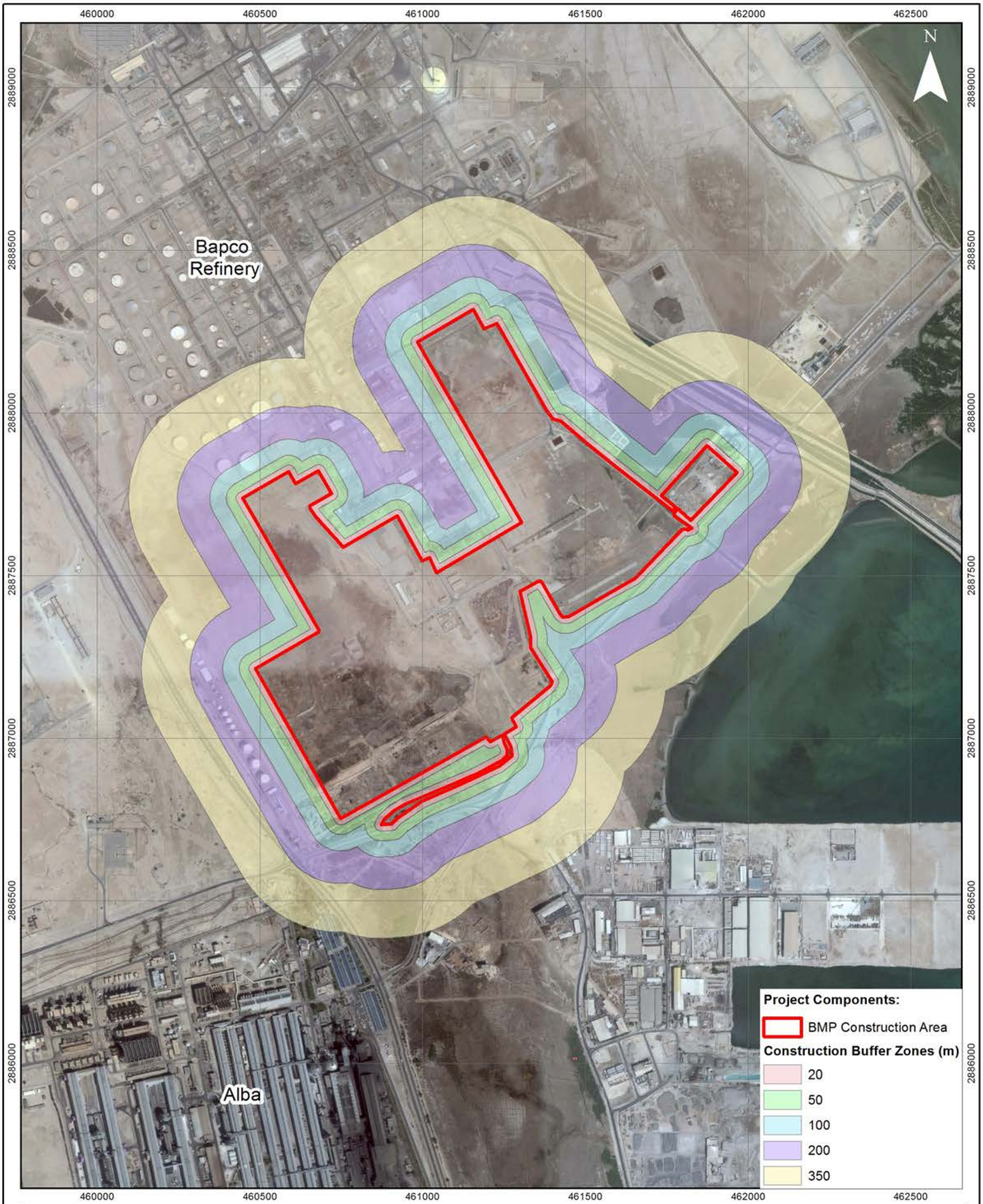
The IAQM guidance (IAQM, 2014) states that a detailed assessment is required if there are human receptors located within 350m and ecological receptors within 50m of the site boundary. A detailed assessment is also required if an ecological or human report is located closer than 50 m of the route(s) used by construction vehicles on the public highway, up to 500 m from the site entrance(s).

The assessment identified that there were no human or ecological receptors located within the adopted screening criteria buffer distances. In accordance with the IAQM guidance, the risk of construction dust effects is negligible and any effects will be insignificant. The construction phase will nonetheless implement construction dust mitigation measures to minimise emissions in accordance with best practices. These practices will be defined within the dust management/mitigation plan for the proposed construction activities.

The distance boundaries for the construction phase assessment are detailed in **Figure 6. 7**.

Although not considered a construction area as such, there are no sensitive receptors within 350m of the proposed contractor's lay down area. The proposed route between the lay down area and Bapco Refinery does not pass within 50m of any residential receptor location.

Cumulative impacts of other potential construction activities in the area have not been described due to predicted impacts from the BMP being considered to be negligible.



	Title: **Construction Dust Buffer Zones**		Client: Bapco Technip
	Project: Bapco Modernization Program		
	Date: June 2016	Figure No.: 6.7	Consultant: Environment Arabia
	Datum: WGS 84 - UTM 39N	Scale: 1:15,000 (A4)	

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6.5.1.2 Construction Phase – Air Quality

The proposed BMP is a phased development with processes being constructed over a number of years. As such the level of construction traffic over the lifetime of the project is not known. The phased nature of the BMP however means that the requirement of construction vehicles and staff during the construction phase will be spread over a long timeframe.

Assessment guidance (IAQM,2005) suggests that air quality impacts are unlikely to require detailed assessment and can be considered insignificant under the following conditions:

- Total additional vehicle movements are below 500 Annual Average Daily Traffic (AADT) movements; and
- Total additional heavy duty vehicle movements are below 100 Annual Average Daily Traffic (AADT) movements.

Where the frequency of construction vehicle movements do not exceed the screening criteria, impacts are likely to be negligible. Using screening model techniques, 100 additional HGV movements on an urban road travelling at an average speed of 30km/h would give rise to a total NO_x impact of 0.22µg.m^{-3} at 50m from the roadside, reducing to 0.07µg.m^{-3} at 100m and 0.01µg.m^{-3} at 200m. PM_{10} impacts at 50m would be 0.01µg.m^{-3}, and below this level at greater distances.

It is not expected that these criteria would be breached on an annual basis during the BMP construction phase. The establishment of laydown and contractor areas in positions distanced from residential receptors, to the southwest of the Bapco Refinery, will reduce the potential impacts of construction traffic impacts as the majority of vehicle trips would not use roads near to sensitive receptors.

As the impact of construction traffic at receptor locations is likely to be negligible, no further assessment has been conducted.

6.5.1.3 Operation Phase

The AERMOD dispersion model was used to predict contributions of annual and short-term NO_2, SO_2, CO and PM_{10} concentrations due to implementation of the BMP project. Summary results are provided as **Table 6.11** with the maximum predicted future concentrations at all receptor locations detailed in **Tables 6.12 – 6.14.** Isopleths for all model runs are included in **Appendix 6A**, but **Figures 6.8** to **6.11** reproduce key isopleths for annual mean and 24 hour mean for NO_2 and $SO_{2,}$ post-BMP emission scenarios respectively.

The dispersion model outputs predicted that the implementation of the BMP is unlikely to cause an exceedence of any of the Bahrain National Standards or international surrogate standards adopted within this assessment.

Dispersion modelling of the BMP scenario showed that SO_2 concentrations are likely to be reduced at all receptor locations compared to the existing baseline situation. Concentrations of NO_2 and PM_{10} were predicted to decline at the worst affected receptors, R13-R15, compared to the baseline scenario. Despite this reduction at receptors with the highest predicted PECs, NO_2 and PM_{10} concentrations were predicted to increase, by a smaller magnitude, at other receptor locations. This represents a position where the total emissions of NO_2 and PM_{10} would remain largely constant between the two scenarios but the location of the emission sources and dispersion parameters is reflected in a change in the location of off-site effects. Pollutant dispersion is improved with concentrations at previous poor air quality hot spots being reduced (locations in East Riffa near to the AQMS), with increases observed at locations set further back from the refinery, where PECs were lower.

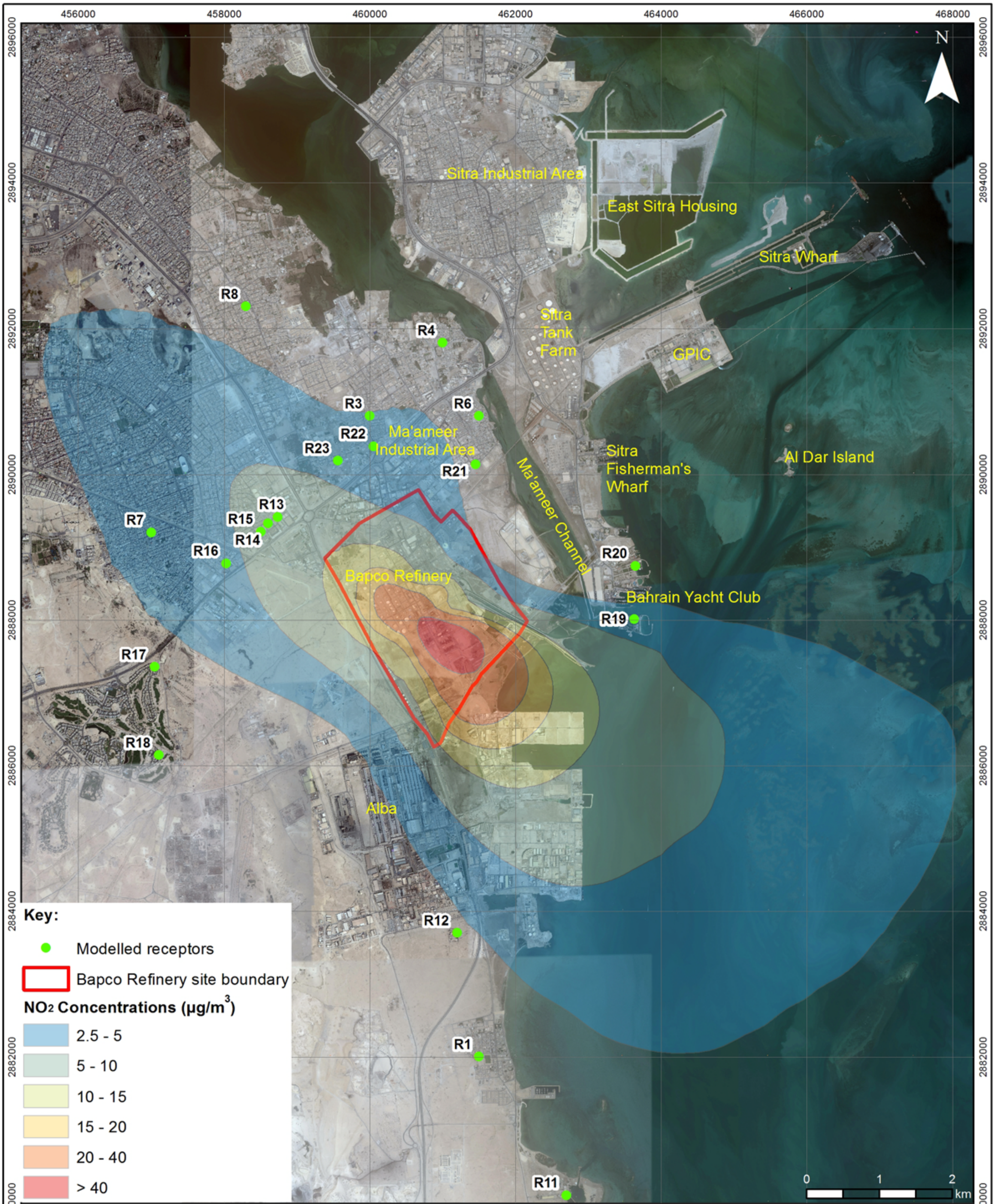
Concentrations of CO were predicted to increase with implementation of the BMP at receptor locations, however this increase, a maximum of 62.0 µg.m^{-3} at any one receptor location, is considered to be negligible compared to the air quality standard of 10 mg.m^{-3} (10,000 µg.m^{-3}).

Table 6.11 BMP Scenario – Modelled Concentrations at Worst Case Receptor

Pollutant	Averaging Period	PC µg.m^{-3}	National standard µg.m^{-3}	WHO Guideline µg.m^{-3}	% of Std or Guideline
SO_2	Maximum hourly value	56.4	350	-	16.1%
	24 hour maximum value	26.3	125	-	21.1%
	Annual Average	2.9	50	-	5.8%
NO_2	Maximum hourly value	64.1	200	-	32.0%
	24 hour maximum value	32.3	150	-	21.6%
	Annual Average	6.6	40	-	16.4%
CO	Maximum 8 hourly value -rolling mean	62.0	10,000	-	0.6%
PM_{10}	24 hour maximum value	14.5	340	-	4.3%
	Annual Average	1.6	-	20	8.0%

Table 6.12 BMP Scenario – Modelled Concentrations of NO_2

Receptor	Pollutant Concentration – $\mu g.m^{-3}$											
	Annual Mean				Maximum 24 Hour Mean				Maximum 1 Hour Value			
	AQS - 40				AQS - 150				AQS - 200			
	PC	PEC Base	PEC With BMP	Change	PC	PEC Base	PEC With BMP	Change	PC	PEC Base	PEC With BMP	Change
R1	1.7	14.8	14.8	0.0	8.9	34.7	35.1	0.4	47.0	69.9	105.1	3.3
R2	1.5	14.6	14.6	0.0	8.6	34.4	34.8	0.4	40.6	65.3	100.8	1.5
R3	2.8	15.9	15.9	0.0	20.9	47.1	47.1	0.0	60.2	87.2	118.3	-0.8
R4	2.0	15.0	15.1	0.1	15.6	41.1	41.8	0.7	52.0	76.0	110.2	2.2
R5	0.8	13.8	13.9	0.1	9.1	35.6	35.3	-0.3	40.4	65.6	99.1	1.0
R6	1.8	14.7	14.9	0.2	11.8	37.0	38.0	1.0	58.5	83.1	116.7	1.6
R7	3.1	16.2	16.2	0.0	15.1	41.4	41.3	-0.1	47.7	73.1	106.6	0.8
R8	1.9	15.0	15.0	0.0	14.0	40.4	40.2	-0.2	47.3	71.4	105.9	2.1
R9	0.7	13.8	13.8	0.0	7.3	33.4	33.5	0.1	36.8	61.8	95.0	1.2
R10	0.4	13.5	13.5	0.0	6.1	31.8	32.3	0.5	34.6	59.9	92.8	0.9
R11	1.6	14.6	14.7	0.1	8.4	34.3	34.6	0.3	41.2	64.1	100.5	3.3
R12	2.6	15.6	15.7	0.1	14.3	40.1	40.5	0.4	52.0	74.0	111.3	4.2
R13 - AQMS	6.6	20.1	19.7	-0.4	32.3	62.2	58.5	-3.7	60.6	90.4	119.7	-3.6
R14	6.3	19.7	19.4	-0.3	31.2	59.5	57.4	-2.1	59.6	88.8	118.8	-3.0
R15	6.0	19.3	19.1	-0.2	28.5	57.3	54.7	-2.6	58.7	87.7	117.9	-2.8
R16	4.4	17.5	17.5	0.0	20.8	46.7	47.0	0.3	55.3	81.7	114.3	-0.2
R17	1.9	14.9	15.0	0.1	15.9	40.9	42.1	1.2	48.4	72.8	107.3	1.8
R18	1.2	14.2	14.3	0.1	13.3	39.1	39.5	0.4	46.4	71.5	105.1	1.1
R19	4.2	17.9	17.3	-0.6	16.4	42.7	42.6	-0.1	57.8	84.8	117.0	-0.8
R20	1.2	14.5	14.3	-0.2	8.0	35.2	34.2	-1.0	56.7	81.2	116.3	1.7
R21	1.9	14.7	15.0	0.3	11.9	36.5	38.1	1.6	63.9	89.3	122.3	0.8
R22	3.2	16.3	16.3	0.0	24.5	50.9	50.7	-0.2	64.1	94.3	122.4	-4.0
R23	3.7	16.9	16.8	-0.1	23.4	50.7	49.6	-1.1	60.7	92.1	119.3	-5.2



Title: BMP Scenario NO_2 Concentrations ($\mu g/m^3$), Annual Mean 2015		Client: Bapco Technip
Project: Bapco Modernization Program		
Date: June 2016	Figure No.: 6.8	Consultant: Environment Arabia
Datum: WGS 84 - UTM 39N	Scale: 1:65,000 (A4)	

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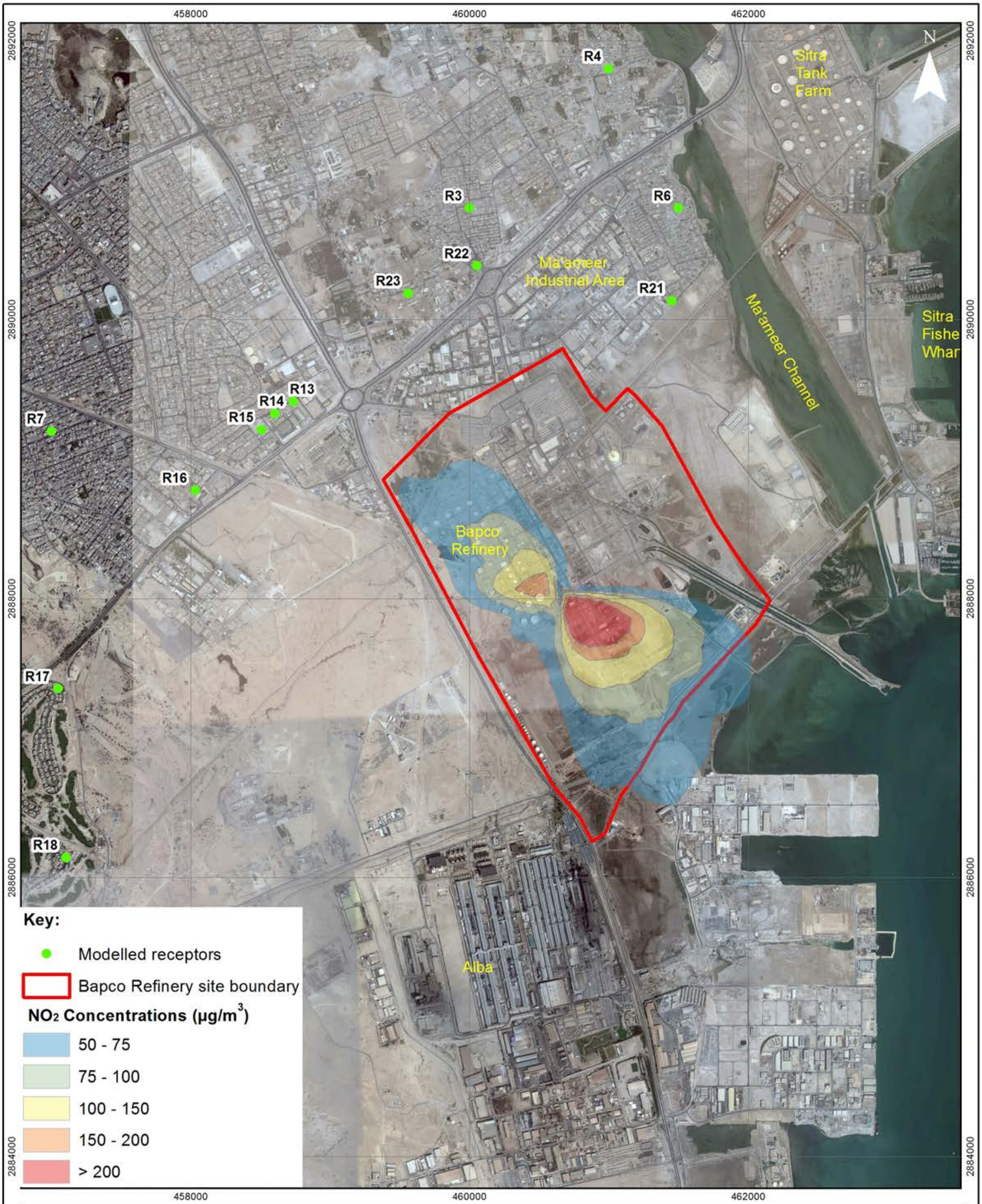

Title: BMP Scenario NO_2 Concentrations (µg/m^3), Maximum 24 Hour Mean - 2013			Client: Bapco Technip
Project: Bapco Modernization Program			
Date: June 2016	Figure No.: 6.9		Consultant: Environment Arabia
Datum: WGS 84 - UTM 39N	Scale: 1:65,000 (A4)		

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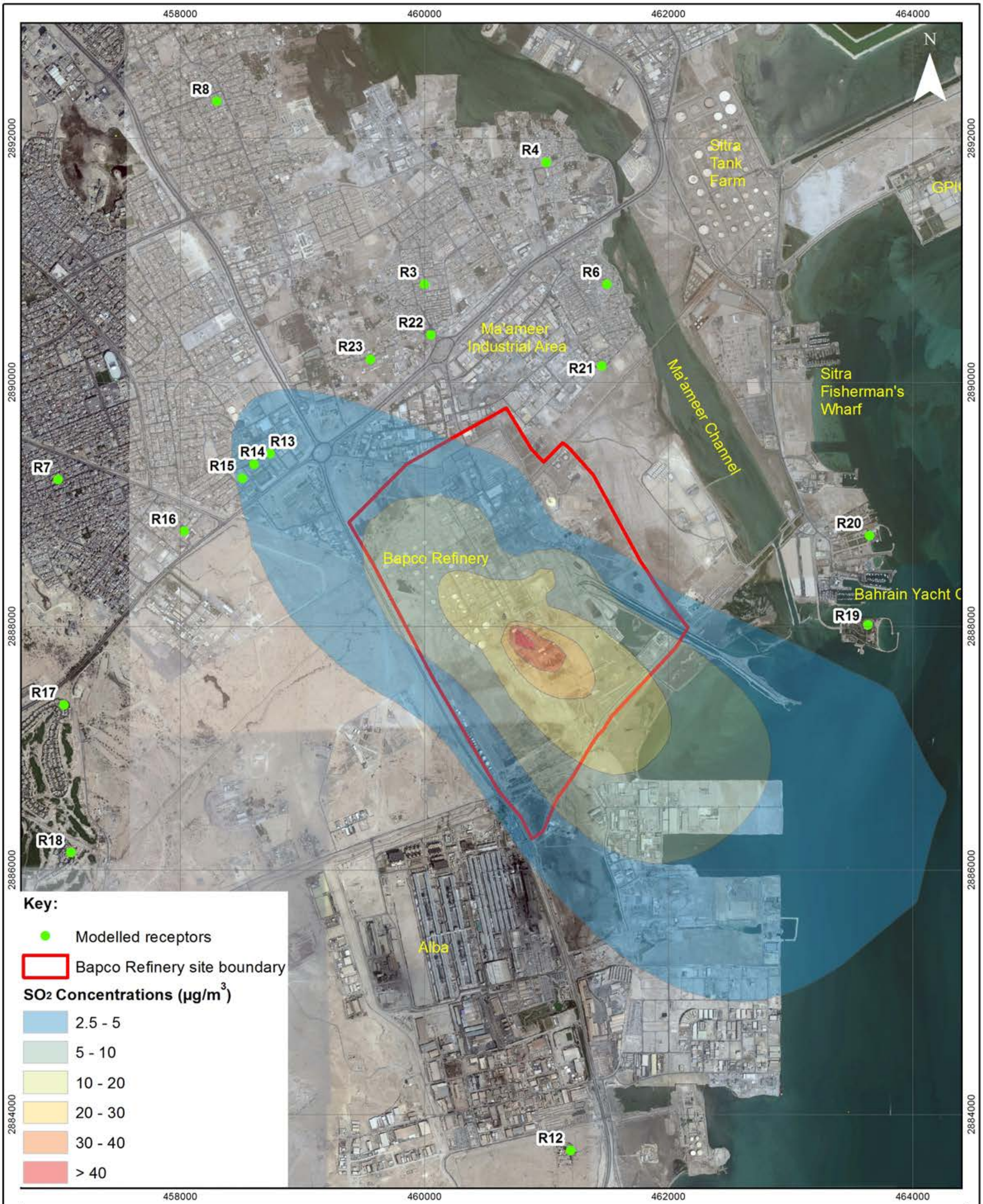
Table 6.13 BMP Scenario – Modelled Concentrations of SO_2

Receptor	Pollutant Concentration – µg.m^{-3}											
	Annual Mean AQS – 50				Maximum 24 Hour Mean AQS - 125				Maximum 1 Hour Value AQS - 350			
	PC	PEC Base	PEC With BMP	Change	PC	PEC Base	PEC With BMP	Change	PC	PEC Base	PEC With BMP	Change
R1	0.7	20.1	19.6	-0.5	6.9	52.1	44.7	-7.4	37.9	81.7	75.7	-6.0
R2	0.6	20.0	19.5	-0.4	7.0	49.8	44.8	-5.0	35.9	79.8	73.7	-6.1
R3	1.3	20.8	20.2	-0.6	18.7	66.0	56.5	-9.5	51.8	123.2	89.6	-33.6
R4	0.9	20.1	19.8	-0.3	13.1	56.5	50.9	-5.6	43.7	102.9	81.5	-21.4
R5	0.3	19.4	19.2	-0.2	7.7	50.1	45.5	-4.6	32.8	80.4	70.6	-9.8
R6	0.8	20.0	19.7	-0.3	10.1	52.8	47.9	-4.9	48.7	120.3	86.5	-33.9
R7	1.3	21.1	20.2	-1.0	12.6	60.1	50.4	-9.7	39.4	99.3	77.2	-22.1
R8	0.8	20.2	19.7	-0.4	11.3	54.9	49.1	-5.8	40.5	88.9	78.3	-10.5
R9	0.3	19.4	19.2	-0.2	5.9	46.4	43.7	-2.7	30.4	72.8	68.2	-4.6
R10	0.2	19.2	19.1	-0.1	4.8	44.5	42.6	-1.9	28.1	71.0	65.9	-5.2
R11	0.6	20.0	19.5	-0.5	6.8	49.1	44.6	-4.5	35.8	75.8	73.6	-2.2
R12	1.0	20.7	19.9	-0.8	11.0	60.5	48.8	-11.7	43.6	93.3	81.4	-11.9
R13 - AQMS	2.9	23.9	21.8	-2.1	26.3	90.6	64.1	-26.5	50.5	134.4	88.3	-46.1
R14	2.7	23.6	21.6	-2.0	24.8	85.3	62.6	-22.7	49.5	131.8	87.3	-44.5
R15	2.6	23.4	21.5	-1.9	23.0	83.9	60.8	-23.1	48.6	130.5	86.4	-44.1
R16	1.8	22.2	20.7	-1.5	16.2	67.1	54.0	-13.1	44.8	118.7	82.6	-36.1
R17	0.8	20.3	19.7	-0.6	12.4	55.0	50.2	-4.8	38.8	99.3	76.6	-22.6
R18	0.5	19.8	19.4	-0.4	11.0	54.8	48.8	-6.0	37.1	95.2	74.9	-20.2
R19	2.0	22.4	20.9	-1.4	13.5	60.2	51.3	-8.9	42.5	120.9	80.3	-40.6
R20	0.7	19.9	19.6	-0.4	8.3	49.9	46.1	-3.8	41.4	111.6	79.2	-32.5
R21	0.8	20.1	19.7	-0.3	10.0	54.3	47.8	-6.5	53.2	132.3	91.0	-41.3
R22	1.5	21.2	20.4	-0.8	22.2	71.6	60.0	-11.6	56.4	137.0	94.2	-42.8
R23	1.8	21.7	20.7	-1.0	20.2	71.8	58.0	-13.8	53.4	135.1	91.2	-44.0



Title: BMP Scenario SO_2 Concentrations (µg/m^3), Annual Mean 2015			Client: Bapco Technip
Project: Bapco Modernization Program			
Date: June 2016	Figure No.: 6.10		Consultant: Environment Arabia
Datum: WGS 84 - UTM 39N	Scale: 1:65,000 (A4)		

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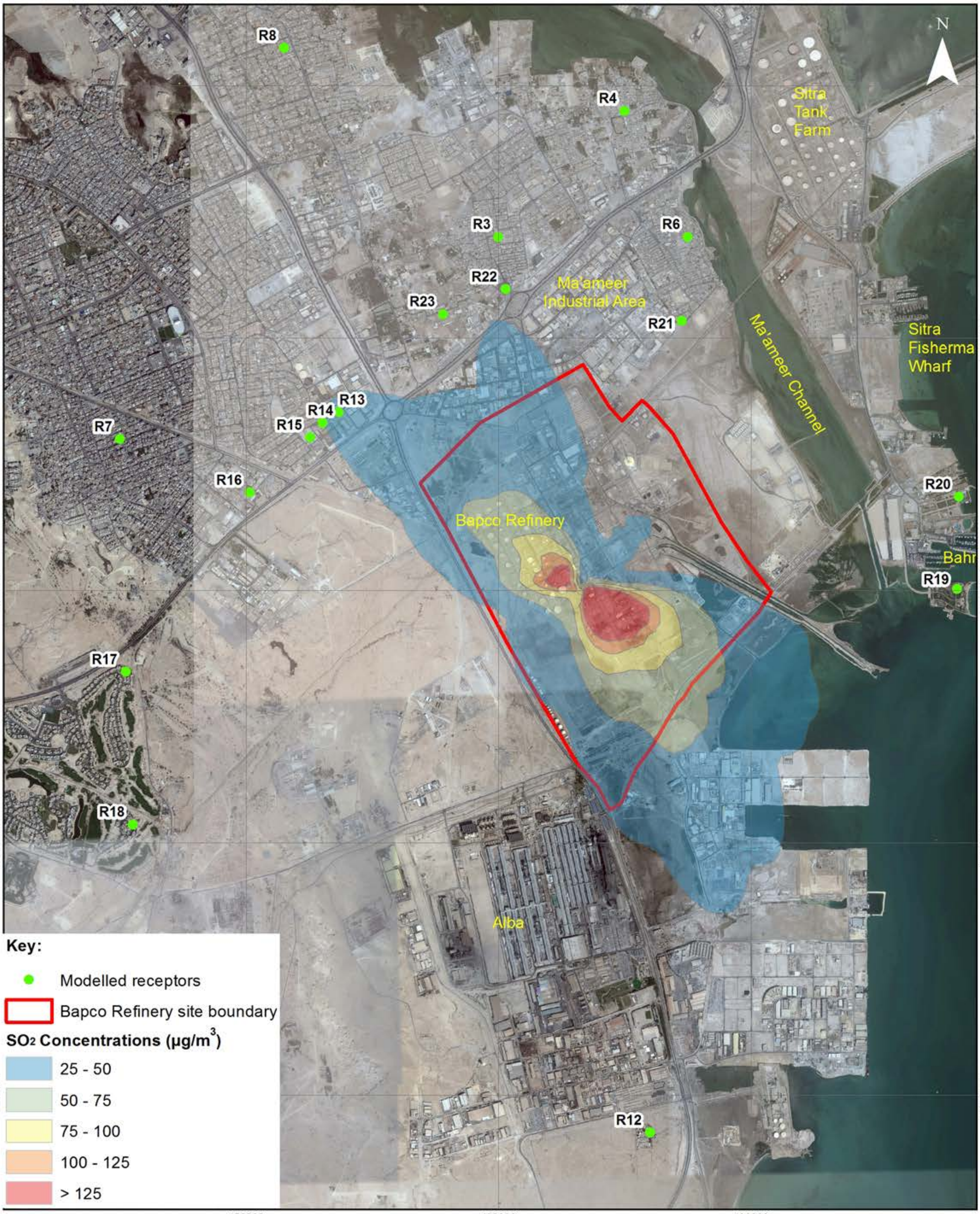

Title: **BMP Scenario SO_2 Concentrations (µg/m³), Maximum 24 Hour Mean 2013**

Client: Bapco, Technip

Project: Bapco Modernization Program

Date: June 2016

Figure No.: 6.11

Datum: WGS 84 - UTM 39N

Scale: 1:65,000 (A4)

Consultant: Environment Arabia

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Table 6.14 BMP Scenario – Modelled Concentrations of CO and PM_{10}

Receptor	Pollutant Concentration – µg.m^{-3}											
	CO Maximum 8 Hour Rolling Mean				PM_{10} - Annual Mean				PM_{10} – Maximum 24 Hour Mean			
	AQS – 10,000				AQS - 20				AQS - 340			
	PC	PEC Base	PEC With BMP	Change	PC	PEC Base	PEC With BMP	Change	PC	PEC Base	PEC With BMP	Change
R1	17.9	1614.7	1617.9	3.2	0.4	120.4	120.4	0.0	4.0	243.7	244.0	0.3
R2	18.3	1617.4	1618.3	0.9	0.3	120.3	120.3	0.0	3.8	243.8	243.8	0.0
R3	55.9	1646.1	1655.9	9.8	0.7	120.7	120.7	0.0	10.9	250.5	250.9	0.4
R4	42.7	1631.8	1642.7	10.9	0.5	120.5	120.5	0.0	7.5	246.9	247.5	0.6
R5	23.9	1620.0	1623.9	3.9	0.2	120.2	120.2	0.0	4.2	244.3	244.2	-0.1
R6	39.3	1630.0	1639.3	9.3	0.5	120.4	120.5	0.1	5.7	245.4	245.7	0.3
R7	33.8	1627.4	1633.8	6.4	0.7	120.7	120.7	0.0	6.7	246.7	246.7	0.0
R8	33.9	1627.1	1633.9	6.8	0.5	120.5	120.5	0.0	6.1	246.2	246.1	-0.1
R9	14.0	1612.8	1614.0	1.2	0.2	120.2	120.2	0.0	3.3	243.3	243.3	0.0
R10	13.0	1611.3	1613.0	1.7	0.1	120.1	120.1	0.0	2.7	242.4	242.7	0.3
R11	20.7	1617.2	1620.7	3.5	0.4	120.3	120.4	0.1	3.8	243.5	243.8	0.3
R12	23.6	1621.3	1623.6	2.3	0.6	120.6	120.6	0.0	6.6	246.1	246.6	0.5
R13 - AQMS	50.8	1643.0	1650.8	7.8	1.6	121.7	121.6	-0.1	14.5	255.9	254.5	-1.4
R14	50.0	1642.4	1650.0	7.6	1.5	121.6	121.5	-0.1	13.4	254.6	253.4	-1.2
R15	49.5	1641.4	1649.5	8.1	1.4	121.5	121.4	-0.1	13.1	254.5	253.1	-1.4
R16	40.8	1633.4	1640.8	7.4	1.0	121.0	121.0	0.0	9.2	249.9	249.2	-0.7
R17	28.1	1622.0	1628.1	6.1	0.4	120.4	120.4	0.0	7.2	247.2	247.2	0.0
R18	26.8	1623.6	1626.8	3.2	0.3	120.3	120.3	0.0	6.0	245.7	246.0	0.3
R19	42.1	1636.8	1642.1	5.3	1.1	121.2	121.1	0.0	7.6	247.9	247.6	-0.3
R20	33.0	1638.8	1633.0	-5.8	0.3	120.4	120.3	-0.1	4.1	244.9	244.1	-0.8
R21	38.7	1628.3	1638.7	10.4	0.5	120.4	120.5	0.1	6.0	245.5	246.0	0.5
R22	62.0	1651.4	1662.0	10.6	0.8	120.9	120.8	-0.1	12.9	252.6	252.9	0.3
R23	55.7	1647.1	1655.7	8.6	1.0	121.0	121.0	0.0	10.8	251.7	250.8	-0.9

Environment Arabia

6.5.1.4 Significance of Effects

The assessment has used the IFC guidance to assess the significance of the proposed BMP. The assessment concludes that implementation of the BMP is not predicted to result in pollutant concentrations that exceed the relevant air quality standards. None of the Bahrain National Standards were predicted to be exceeded with or without the implementation of the BMP. The WHO PM_{10} annual mean air quality guideline is exceeded both with and without the development, with concentrations at the worst case receptors improving in the BMP scenario.

With only one exception, emissions from the facility after implementation of the BMP are predicted to contribute less than 25% of the relevant air quality standards. The exception to this was comparison to the NO_2 hourly maximum air quality standard where the process contribution of the facility after implementation of the BMP was predicted to be 32.0% of the relevant air quality standard. It should be noted that despite this contribution to the air quality standard, the implementation of the BMP would give rise to a reduction in the PC (from 34.1%) at the worst case receptor.

The assessment concluded that the air quality effects of the implementation of the BMP were not considered to be significant when compared to the IFC significance criteria. There will be an overall benefit in terms of reduced SO_2 effects at receptor locations, and NO_2 and PM_{10} effects will be improved at the worst-affected locations. The process contribution of CO at receptor locations is considered to be insignificant for both the baseline and post BMP scenarios.

Table 6.15 summarises the changes in the PC values at each receptor resulting from the BMP implementation, as a percentage of the respective air quality standard or guideline, and also the average and maximum percentage changes across the range of receptor locations. The table shows the extent of beneficial impacts (as negative changes) for SO_2. It also shows that the maximum impact of the BMP at any receptor is approximately 2% of the relevant standard for the peak 1-hour NO_2 concentration, around 1% for annual and 24-hour NO_2 concentrations, and below 1% for 8-hour CO, and annual and 24-hour PM_{10} values.

Environment Arabia

Table 6.15 Change in PC from BMP Implementation as a Percentage of the AQS

Receptor	Change in PC from BMP Implementation as a Percentage of the AQS								
	SO_2			NO_2			CO	PM_{10}	
	Annual	Max 24-h	Max 1-h	Annual	Max 24-h	Max 1-h	Max 8-h	Annual	Max 24-h
R1	-1.0%	-5.9%	-1.7%	0.0%	0.3%	1.7%	0.0%	0.0%	0.1%
R2	-1.0%	-4.0%	-1.7%	0.0%	0.3%	0.8%	0.0%	0.0%	0.0%
R3	-1.2%	-7.6%	-9.6%	0.0%	0.0%	-0.4%	0.1%	0.0%	0.1%
R4	-0.6%	-4.5%	-6.1%	0.3%	0.5%	1.1%	0.1%	0.0%	0.2%
R5	-0.4%	-3.7%	-2.8%	0.3%	-0.2%	0.5%	0.0%	0.0%	0.0%
R6	-0.6%	-3.9%	-9.7%	0.5%	0.7%	0.8%	0.1%	0.5%	0.2%
R7	-1.8%	-7.8%	-6.3%	0.0%	-0.1%	0.4%	0.1%	0.0%	0.1%
R8	-1.0%	-4.6%	-3.0%	0.0%	-0.1%	1.1%	0.1%	0.0%	0.0%
R9	-0.4%	-2.2%	-1.3%	0.0%	0.1%	0.6%	0.0%	0.0%	0.1%
R10	-0.2%	-1.5%	-1.5%	0.0%	0.3%	0.4%	0.0%	0.0%	0.1%
R11	-1.0%	-3.6%	-0.6%	0.3%	0.2%	1.7%	0.0%	0.5%	0.1%
R12	-1.6%	-9.4%	-3.4%	0.3%	0.3%	2.1%	0.0%	0.0%	0.2%
R13 - AQMS	-4.2%	-21.2%	-13.2%	-1.0%	-2.5%	-1.8%	0.1%	-0.5%	-0.4%
R14	-4.0%	-18.2%	-12.7%	-0.8%	-1.4%	-1.5%	0.1%	-0.5%	-0.4%
R15	-3.8%	-18.5%	-12.6%	-0.5%	-1.7%	-1.4%	0.1%	-0.5%	-0.4%
R16	-3.0%	-10.5%	-10.3%	0.0%	0.2%	-0.1%	0.1%	0.0%	-0.2%
R17	-1.2%	-3.8%	-6.5%	0.3%	0.8%	0.9%	0.1%	0.0%	0.9%
R18	-0.8%	-4.8%	-5.8%	0.3%	0.3%	0.6%	0.0%	0.0%	0.1%
R19	-3.0%	-7.1%	-11.6%	-1.5%	-0.1%	-0.4%	0.1%	0.0%	-0.1%
R20	-0.6%	-3.0%	-9.3%	-0.5%	-0.7%	0.9%	-0.1%	-0.5%	-0.2%
R21	-0.8%	-5.2%	-11.8%	0.8%	1.1%	0.4%	0.1%	0.5%	0.3%
R22	-1.6%	-9.3%	-12.2%	0.0%	-0.1%	-2.0%	0.1%	-0.5%	0.1%
R23	-2.0%	-11.0%	-12.5%	-0.2%	-0.7%	-2.6%	0.1%	0.0%	-0.3%
Average % of all receptors	**-1.6%**	**-7.4%**	**-7.2%**	**-0.1%**	**-0.1%**	**0.2%**	**0.1%**	**0.0%**	**0.0%**
Maximum % of all receptors	**-0.2%**	**-1.5%**	**-0.6%**	**0.8%**	**1.1%**	**2.1%**	**0.1%**	**0.5%**	**0.9%**

6.5.1.5 GHG Emissions – Operational Phase

The predicted annual GHG emissions from the Post-BMP Refinery are detailed in **Table 6.16**. The calculation is provided in **Appendix 6A**.

Table 6.16 Predicted Refinery GHG Emissions Post-BMP

Activity	Post-BMP
Consumption of Generated Process Gas (kt CO_2e)	3518
Consumption of Electricity (kt CO_2e)	978
Total (kt CO_2e)	4496

6.5.1.6 Cumulative Impacts

This ESIA has identified that there is potential for cumulative impacts of the BMP with the Alba Line 6 development. An evaluation of the air quality assessment associated with the Alba Line 6 ESIA was undertaken to give an indication of potential cumulative impacts (Bilfinger, 2014).

When considering cumulative impacts it must be noted that:

- The individual assessments do not consider the same receptor locations;
- The location of maximum impacts of any two or more significant industrial development will vary;
- The modelling software, meteorological dispersion data and other assessment tools may be different;
- Background air pollutant concentration data, meteorological period and terrain data that would have been appropriate for use in the Alba Line 6 assessment in 2009, have been updated.
- It is not considered appropriate to compare maximum short term (hourly) conditions from the two developments. As the two facilities are located more than 1.5km apart it is considered very unlikely that peak source emissions and associated maximum hourly ground level concentrations would coincide. Therefore long-term (annual average) cumulative effects are considered.

A comparison of predicted annual mean SO_2 and NO_2 concentrations at East Riffa, the area likely to be most affected by the Bapco facility emissions, is provided in **Table 6.17**. The assessment has assumed that the Alba Scenario 3 will be implemented, which incorporates the impact of proposed mitigation measures.

Table 6.17 Cumulative Impacts at East Riffa

Pollutant	Standard	Background	PC		Total
			BMP	Alba	
SO_2 - Annual Mean ($\mu g.m^{-3}$)	50	18.9	2.9	4.7	26.5
NO_2 - Annual Mean ($\mu g.m^{-3}$)	40	13.1	6.6	0.4	20.1

The comparison indicates that the BMP is anticipated to give rise to a greater contribution to annual mean NO_2 concentrations at East Riffa, whereas implementation of the Alba Line 6 project would have a greater effect on SO_2 levels in this location. Table 6.16 shows that at the East Riffa receptors which are predicted to be exposed to maximum impacts from the BMP, emissions from the Alba expansion would also contribute to ambient NO_2 and SO_2 concentrations. However, when also accounting for the existing background concentrations, the combined maximum effect would remain well below the respective Bahrain national Standards for annual mean SO_2 and NO_2.

6.6 Mitigation and Monitoring

The facility has incorporated a number of mitigation measures into the scheme in order to minimise the air quality impact at receptor locations. The mitigation measures incorporated into the scheme are detailed in Section 6.6.1, Construction Phase and 6.6.2, Operational Phase.

6.6.1 Construction Phase

The assessment concluded that there is a negligible risk of construction dust effects as receptors are located outside the zones where an impact is likely to occur. Construction dust mitigation will however be implemented in order to minimise emissions in accordance with good practice construction management. The following appropriate and relevant examples from the IAQM guidance would be expected to be applied by the Contractor:

Recommended measures for Low impact sites.

Communications

- Develop and implement a stakeholder communications plan that includes community engagement before work commences on site.
- Display the name and contact details of person(s) accountable for air quality and dust issues on the site boundary. This may be the environment manager/engineer or the site manager.
- Display the head or regional office contact information.

Dust Management

- Record all dust and air quality complaints, identify cause(s), take appropriate measures to reduce emissions in a timely manner, and record the measures taken.
- Record any exceptional incidents that cause dust and/or air emissions, either on- or offsite, and the action taken to resolve the situation in the log book.
- Increase the frequency of site inspections by the person accountable for air quality and dust issues on site when activities with a high potential to produce dust are being carried out and during prolonged dry or windy conditions.
- Plan site layout so that machinery and dust causing activities are located away from receptors, as far as is practicable.
- Erect solid screens or barriers around dusty activities or the site boundary that are at least as high as any stockpiles on site.
- Ensure all vehicles switch off engines when stationary - no idling vehicles.

- Were possible, avoid the use of diesel or petrol powered generators and use mains electricity or battery powered equipment where practicable.
- Only use cutting, grinding or sawing equipment fitted or in conjunction with suitable dust suppression techniques such as water sprays or local extraction, e.g. suitable local exhaust ventilation systems.
- Use enclosed chutes and conveyors and covered skips.
- Minimise drop heights from conveyors, loading shovels, hoppers and other loading or handling equipment and use fine water sprays on such equipment wherever appropriate.
- Bonfires and burning of waste materials should not be permitted.

Measures Specific to Non Road Mobile Machinery (NRMM)

- All NRMM should use fuel equivalent to ultralow sulphur diesel (fuel meeting the specification within EN590:2004).
- All NRMM should be fitted with Diesel Particulate Filters (DPF) conforming to defined and demonstrated filtration efficiency (load/duty cycle permitting).
- The ongoing conformity of plant retrofitted with DPF, to a defined performance standard, should be ensured through a programme of onsite checks.
- Implementation of fuel conservation measures including instructions to throttle down or switch off idle construction equipment; switch off the engines of trucks while they are waiting to access the site and while they are being loaded or unloaded, ensure equipment is properly maintained to ensure efficient energy consumption.

Desirable measures for Low impact sites

Dust Management

- Remove materials that have a potential to produce dust from site as soon as possible.
- Cover or fence stockpiles to prevent wind whipping.
- Impose and signpost a maximum-speed-limit of 30 kph on surfaced, and 20 kph on unsurfaced, haul roads and work areas (if long haul routes are required these speeds may be increased with suitable additional control measures provided, subject to the approval of the nominated undertaker and with the agreement of the local authority, where appropriate)

Measures Specific to Construction

- Ensure sand and other aggregates are stored in silos, bunded areas or in a controlled and well-managed manner.
- Avoid scabbling (roughening of concrete surfaces) if possible.

Measures Specific to Trackout

- Ensure vehicles entering and leaving sites are covered to prevent escape of materials during transport.

- Record all inspections of haul routes and any subsequent action in a site log book.

6.6.2 Operational Phase Mitigation and Monitoring

Bapco are required to report their emissions to air to the SCE every six months using the correct form (Half yearly Environmental Compliance Report). This is already part of Bapco's procedures. The compliance data will comprise a combination of predicted emissions (using its Predictive Emissions Monitoring System (PEMS)), emissions by calculations and stack tests. The approach of using PEMS as continuous online monitoring has previously been agreed with the SCE.

Ministerial Order No. 10 of 2006 with respect to air pollutant emissions requires a continuous emissions monitoring system (CEMS) for all significant stacks and requires this information to be reported continuously to the SCE. This system has never been effectively implemented by SCE due to technical issues. There is presently no time line for this law to be implemented by SCE. Should it be implemented in the future then Bapco will need to agree with the SCE which stacks would require emissions online monitoring and would need to provide relevant emissions data to the SCE.

As part of IFC requirements all projects with annual carbon dioxide emissions in excess of 25,000 tonnes per year should prepare an annual report of greenhouse gas (GHG) emissions in accordance with internationally recognized methodologies. The Equator Principles III require that any project with annual emissions of GHGs in excess of 100,000 tonnes should report its GHG emissions publically.

6.6.3 The Industrial Emissions Directive (IED) and Operational Phase BAT

6.6.3.1 Summary of Directive 2010/75/EU on industrial emissions (integrated pollution prevention and control)

In the European Union, Directive 2010/75/EU on industrial emissions (the Industrial Emissions Directive or IED) (EU, 2010) is the main instrument regulating pollutant emissions from industrial installations.

The IED was based on a Commission proposal recasting 7 previously existing Directives (including in particular the IPPC Directive). The IED entered into force in January 2011 and had to be transposed by Member States by January 2013.

The IED aims to achieve a high level of protection of human health and the environment taken as a whole by reducing harmful industrial emissions across the EU, in particular through better application of Best Available Techniques (BAT). Installations which are prescribed are required to operate in accordance with a Permit (granted by the Member State's regulatory authority), which sets out conditions in accordance with the principles and provisions of the IED.

The IED is based on several pillars, in particular (1) an integrated approach, (2) use of best available techniques, (3) flexibility, (4) inspections and (5) public participation. The integrated approach means that the permits must take into account the whole environmental performance of the plant, covering e.g. emissions to air, water and land, generation of waste, use of raw materials, energy efficiency, noise, prevention of accidents, and restoration of the site upon closure. The permit conditions including emission limit values must be based on the Best Available Techniques (BAT)[10], which for each sector are laid down in BAT Reference Documents (BREFs); the BAT conclusions contained are adopted by the Commission as Implementing Decisions. The IED requires that these BAT conclusions are the reference for setting permit conditions.

For certain activities, i.e. large combustion plants, waste incineration and co-incineration plants, solvent using activities and titanium dioxide production, the IED also sets EU wide emission limit values for selected pollutants.

The IED allows competent authorities some flexibility to set less strict emission limit values. This is possible only in specific cases where an assessment shows that achieving the emission levels associated with BAT described in the BAT conclusions would lead to disproportionately higher costs compared to the environmental benefits due to the geographical location or the local environmental conditions or the technical characteristics of the installation. The competent authority shall always document its justification for granting such derogations.

Furthermore, Chapter III of the IED on large combustion plants includes certain flexibility instruments (Transitional National Plan, limited lifetime derogation, etc.).

The IED contains mandatory requirements on environmental inspections. The IED requires a site visit to take place at least every 1 to 3 years, using risk-based criteria. Finally, the IED ensures that the public has a right to participate in the decision-making process, and to be informed of its consequences, by having access to permit applications, permits and the results of the monitoring of releases.

Under the former Integrated Pollution Prevention and Control Directive (IPPC) Directive, from 1996 to 2013, BREFs were guidance, and they did not set mandatory emission limits. In general, across the EU, new plant was built to comply with BAT, 'major modifications' included upgrading to BAT, but 'existing' plants were often not upgraded to achieve BAT, with operators presenting the case of cost against environmental benefit. Thus the Commission view was that, in this respect, IPPC was not achieving its objectives.

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[10] *'best available techniques' means the most effective and advanced stage in the development of activities and their methods of operation which indicates the practical suitability of particular techniques for providing the basis for emission limit values and other permit conditions designed to prevent and, where that is not practicable, to reduce emissions and the impact on the environment as a whole:*

*'**techniques**' includes both the technology used and the way in which the installation is designed, built, maintained, operated and decommissioned;*

***'available techniques'** means those developed on a scale which allows implementation in the relevant industrial sector, under economically and technically viable conditions, taking into consideration the costs and advantages, whether or not the techniques are used or produced inside the Member State in question, as long as they are reasonably accessible to the operator; and*

*'**best'** means most effective in achieving a high general level of protection of the environment as a whole.*

With the implementation of the IED from 2013, all BREFs are to be updated (in the period up to 2020). Each BREF will have BAT Conclusions (BATc)[11] used as reference for setting permit conditions; the BATc documents contain a BAT 'narrative', the techniques without numerical limits, and BAT Associated Emission Levels (BAT-AELs). Once the new BREFs and BATc are published, existing plants must comply with the BAT-AEL within 4 years, unless they are granted a derogation because compliance would lead to disproportionately higher costs compared to the environmental benefits. This balance is made in consideration of geographical location, local environmental conditions and/or technical characteristics.

Some BREFs were started under IPPC regime and completed under IED (with BATc), and these included the *Refining Mineral Oil and Gas* sector[12]. BAT Conclusions under production include *Large Volume Organic Chemicals*[13], and *Large Combustion Plants*[14]. The *Emissions from Storage* BREF[15] has not yet been updated from the 2006 version. Aspects of all these BREFs and BATc documents may be relevant to the Bapco installations.

6.6.3.2 Emissions from Storage BREF

The 2006 Emissions from Storage BREF sets out a methodology for ECM (Emission Control Measures) scorecards for storing, transfer and handling of liquid and liquefied gas. Each scorecard provides information on typical ECM for gaseous and/or liquid emissions and/or waste, and the aspects and factors considered are the storage design, achieved environmental benefit, operability, applicability, safety aspects, energy/waste/cross-media, and economics.

Annex 8.11 describes the use of the assessment matrices, and indicates that this is an iterative approach until the combination of ECM that give the highest overall score meets BAT. However in practice operators have not tended to apply the approach due to its complexity, the lack of account for a number of tanks emitting vapour across an installation, each with a different original design, age profile and maintenance regime, and a shift in BAT emphasis to the local site level.

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[11] *'BAT conclusions' means a document containing the parts of a BAT reference document laying down the conclusions on best available techniques, their description, information to assess their applicability, the emission levels associated with the best available techniques, associated monitoring, associated consumption levels and, where appropriate, relevant site remediation measures.*

[12] Official Journal of the European Union (2014). Commission Implementing Decision of 9 October 2014, reference C(2014)7155, establishing best available techniques (BAT) conclusions, under Directive 2010/75/EU of the European Parliament and of the Council on industrial emissions, for the refining of mineral oil and gas.

[13] European IPPC Bureau Joint Research Centre (2014). Industrial Emissions Directive 2010/75/EU. Best Available Techniques (BAT) Reference Document in the Large Volume Organic Chemical Industry. Draft 1 (April 2014)

[14] European IPPC Bureau Joint Research Centre (2014). Industrial Emissions Directive 2010/75/EU. Best Available Techniques (BAT) Reference Document in Large Combustion Plants. Draft 1 (June 2013)

[15] European Commission (2006). Integrated Pollution Prevention and Control. Reference Document on Best Available Techniques on Emissions from Storage, July 2006

Risk and Reliability Based Maintenance (RRM) is the application of risk-based tools for the optimisation of maintenance and inspection activities, and represents the shift across the sector from a time-based to a condition-based maintenance approach. There are various failure probability and consequences models which are followed, giving rise to routine in-service and out-of-service inspection, maintenance and monitoring strategies. The 2006 BREF provides a review of BAT across the range of tank designs, focusing on vapour containment, (pressure vacuum relief valves), leakage protection and detection systems, operational procedures for filling, and matters of safety and fire protection. The Bapco BMP would be expected to have duly considered these fundamental design and management criteria at FEED.

6.6.3.3 BATc in Refining Mineral Oil and Gas

As outlined above, the BATc produced under the IED regime provide more definitive statements about what represents BAT, rather than ranges of good practice measures which are commonly applied across the industry. The BATc in the refining sector, published as a formal 'Decision' of the European Parliament and of the Council, is a concise document of 45 pages which sets out the general conclusions, covering generic aspects such as Environmental Management Systems, Energy Efficiency, Monitoring, Waste Management, Noise and general Refinery Management. It also provides BATc for specific processes (eg alkylation, cracking, coking, etherification, distillation, combustion, thermal processes such as visbreaking etc), and for storage and handling, and for waste gas sulphur treatment and flaring.

This ESIA does not provide a full BAT review of all the proposed activities in the BMP, but in respect of the key air quality aspects, a summary of the approaches is given below.

Monitoring of emissions to air and key process parameters

- BAT 4 is to monitor emissions to air by using the monitoring techniques with at least the minimum frequency specified, and in accordance with EN standards. If EN standards are not available, BAT is to use ISO, national or other international standards that ensure the provision of data of an equivalent scientific quality. For example, for SOx, NOx, and dust emissions, monitoring should be continuous, except for combustion units <50MW total rated thermal input; SRUs require continuous monitoring of SO_2 only (although this may be replaced by calculations based on measurements of the sulphur content of the fuel or the feed; where it can be demonstrated that this leads to an equivalent level of accuracy). A further example is that ammonia releases are required to be measured continuously from all units equipped with SCR or SNCR (usually direct NH_3 or urea injected for NOx reduction).

- BAT 5 is to monitor the relevant process parameters linked to pollutant emissions at catalytic cracking and combustion units, by using appropriate techniques and with at least the frequency stated. For example, O_2 is required to be measured continuously, and N and S content periodically, at a frequency based on significant fuel/feed changes monitoring in fuel or feed (and this may not be necessary when continuous emission measurements of NOx and SO_2 are carried out at the stack).

- BAT 18 covers integrated refinery management, and in the prevention or reduction of diffuse VOC emissions, BAT is to apply the techniques given in **Table 6.18** below.

Table 6.18 BAT for Diffuse VOC Emissions

	Technique	Description	Applicability
I	Techniques related to plant design	i. limiting the number of potential emission sources ii. maximising inherent process containment features iii. selecting high integrity equipment iv. facilitating monitoring and maintenance activities by ensuring access to potentially leaking components	Applicability may be limited for existing units
II	Techniques related to plant installation and commissioning	i. well-defined procedures for construction and assembly ii. robust commissioning and hand-over procedures to ensure that the plant is installed in line with the design requirements	Applicability may be limited for existing units
III	Techniques related to plant operation	Use of a risk-based leak detection and repair (LDAR) programme in order to identify leaking components, and to repair these leaks. See Section 1.20.6*	Generally applicable
*Where Section 1.20.6 describes the techniques for the prevention and control of emissions to air, for VOCs, as given in **Table 6.19**.			

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Table 6.19 Techniques for the prevention and control of emissions to air – VOCs

Vapour recovery	Volatile organic compounds emissions from loading and unloading operations of most volatile products, especially crude oil and lighter products, can be abated by various techniques e.g.: • Absorption: the vapour molecules dissolve in a suitable absorption liquid (e.g. glycols or mineral oil fractions such as kerosene or reformate). The loaded scrubbing solution is desorbed by reheating in a further step. The desorbed gases must either be condensed, further processed, and incinerated or re-absorbed in an appropriate stream (e.g. of the product being recovered; • Adsorption: the vapour molecules are retained by activate sites on the surface of adsorbent solid materials, e.g. activated carbon (AC) or zeolite. The adsorbent is periodically regenerated. The resulting desorbate is then absorbed in a circulating stream of the product being recovered in a downstream wash column. Residual gas from wash column is sent to further treatment; • Membrane **gas separation**: the vapour molecules are processed through selective membranes to separate the vapour/air mixture into a hydrocarbon- enriched phase (permeate), which is subsequently condensed or absorbed, and a hydrocarbon-depleted phase (retentate). • Two**-stage refrigeration/condensation**:by cooling of the vapour/gas mixture the vapour molecules condense and are separated as a liquid. As the humidity leads to the icing-up of the heat exchanger, a two-stage condensation process providing for alternate operation is required. • Hybrid **systems**: combinations of available techniques *NB*Absorption and adsorption processes cannot notably reduce methane emissions.
Vapour destruction	Destruction of VOCs can be achieved through e.g. **thermal oxidation** (incineration) or **catalytic oxidation** when recovery is not easily feasible. Safety requirements (e.g. flame arrestors) are needed to prevent explosion. **Thermal oxidation** occurs typically in single chamber, refractory-lined oxidisers equipped with gas burner and a stack. If gasoline is present, heat exchanger efficiency is limited and preheat temperatures are maintained below 180 °C to reduce ignition risk. Operating temperatures range from 760 °C to 870 °C and residence times are typically 1 second. When a specific incinerator is not available for this purpose, an existing furnace may be used to provide the required temperature and residence times. **Catalytic oxidation** requires a catalyst to accelerate the rate of oxidation by adsorbing the oxygen and the VOCs on its surface The catalyst enables the oxidation reaction to occur at lower temperature than required by thermal oxidation: typically ranging from 320 °C to 540 °C. A first preheating step (electrically or with gas) takes place to reach a temperature necessary to initiate the VOCs catalytic oxidation. An oxidation step occurs when the air is passed through a bed of solid catalysts.

LDAR (Leak detection and repair) programme	An LDAR (leak detection and repair) programme is a structured approach to reduce fugitive VOC emissions by detection and subsequent repair or replacement of leaking components. Currently, sniffing (described by EN 15446) and optical gas imaging methods are available for the identification of the leaks. **Sniffing method**:The first step is the detection using hand-held VOC analysers measuring the concentration adjacent to the equipment (e.g. by using flame ionisation or photo-ionisation). The second step consists of bagging the component to carry out a direct measurement at the source of emission. This second step is sometimes replaced by mathematical correlation curves derived from statistical results obtained from a large number of previous measurements made on similar components. **Optical gas imaging methods**:Optical imaging uses small lightweight hand-held cameras which enable the visualisation of gas leaks in real time, so that they appear as 'smoke' on a video recorder together with the normal image of the component concerned to easily and rapidly locate significant VOC leaks. Active systems produce an image with a back-scattered infrared laser light reflected on the component and its surroundings. Passive systems are based on the natural infrared radiation of the equipment and its surroundings.
VOC diffuse emissions monitoring	Full screening and quantification of site emissions can be undertaken with an appropriate combination of complementary methods, e.g. Solar occultation flux (SOF) or differential absorption lidar (DIAL) campaigns. These results can be used for trend evaluation in time, cross checking and updating/validation of the ongoing LDAR programme. **Solar occultation flux (SOF)**:The technique is based on the recording and spectrometric Fourier Transform analysis of a broadband infrared or ultraviolet/ visible sunlight spectrum along a given geographical itinerary, crossing the wind direction and cutting through VOC plumes. **Differential absorption LIDAR (DIAL)**:DIAL is a laser-based technique using differential adsorption LIDAR (light detection and ranging) which is the optical analogue of sonic radio wave-based RADAR. The technique relies on the back- scattering of laser beam pulses by atmospheric aerosols, and the analysis of spectral properties of the returned light collected with a telescope.
High-integrity equipment	High-integrity equipment includes e.g.: • valves with double packing seals • magnetically driven pumps/compressors/agitators • pumps/compressors/agitators fitted with mechanical seals instead of packing • high-integrity gaskets (such as spiral wound, ring joints) for critical applications

In respect of flaring, this will be minimised within the BMP; where it is necessary, the BATc techniques are

- **Correct plant design**: includes sufficient flare gas recovery system capacity, the use of high-integrity relief valves and other measures to use flaring only as a safety system for other than normal operations (start-up, shutdown, emergency).

- **Plant management**: includes organisational and control measures to reduce flaring events by balancing RFG system, using advanced process control, etc.

- **Flaring devices design**: includes height, pressure, assistance by steam, air or gas, type of flare tips, etc. It aims at enabling smokeless and reliable operations and ensuring an efficient combustion of excess gases when flaring from non-routine operations.

- **Monitoring and reporting**: Continuous monitoring (measurements of gas flow and estimations of other parameters) of gas sent to flaring and associated parameters of combustion (e.g. flow gas mixture and heat content, ratio of assistance, velocity, purge gas flow rate, pollutant emissions). Reporting of flaring events makes it possible to use flaring ratio as a requirement included in the EMS and to prevent future events. Visual remote monitoring of the flare can also be carried out by using colour TV monitors during flare events.

In summary, Bapco commits to following the main principles of BAT and the IED BAT Conclusions in the design, operation, management and monitoring of the BMP, so far as is practicable and economically viable. The summary criteria set out above represent good practice measures in the refinery sector and as a responsible operator Bapco is already complying with or considering the introduction of these techniques to prevent or minimise emissions.

Such an approach will also ensure compliance with the IPC EHS Guidelines, which recommend the implementation of a LDAR program and a range of illustrative VOC emission controls and the associated control efficiency.

6.6.4 Bapco Commitments

Each of the new emission sources has been designed with a suitable exhaust stack to aid dispersion and avoid building influences. The exhaust stacks for the BMP sources range from 40-80m in height. The exhaust stacks will be fitted with a stack tip aperture which will maintain an efflux velocity of at least 12 $m.s^{-1}$ under normal operational situations.

Bapco are committed to ensuring that emissions from process sources are monitored and reported to the SCE in a continuation of the agreed Predictive Emissions Monitoring System (PEMS), using accredited methodologies. Commissioning tests on BMP sources will be compared to the calculated emissions used in this assessment.

Bapco are required to undertake routine emission monitoring in accordance with SCE requirements and will also maintain its commitment to the SCE by submission of a half yearly environmental compliance report which among other items, identifies required emission testing.

The emissions inventory will be maintained so that an investigation can be conducted if BMP source emissions are higher than those used in this assessment.

The storage tanks and processes which will be built as part of the BMP will be designed to minimise fugitive and evaporative losses and in accordance with the relevant BREF and BATc documents referenced above. Any new storage tanks will also be designed to meet the required criteria set in Ministerial Order No. 10 of 1999 with respect to Environmental Standards (air and water) sets out standards for hydrocarbon storage tank design as detailed in **Section 6.2.2**.

The monitoring of fugitive emissions of VOCs and H_2S will be managed under the principles and procedures identified in the site's current emissions management plan. The emissions management plan details the procedure for monitoring fugitive emissions, the reporting procedure for leaks and a description of both routine and reactive maintenance.

Predicted GHG emissions are greater than the annual threshold, provided in the IFC Performance Standard 3, and the Equator Principles requirements. On this basis and in accordance with IFC PS3 Guidelines, annual and public reporting of GHGs from activities at the Bapco refinery will be undertaken to quantify Scope 1 and Scope 2 emissions during the operational phase.

6.7 Summary

The potential for air quality impacts during the construction and operation of the BMP was considered within the ESIA chapter. The assessment concluded that construction phase impacts, both fugitive dust and direct pollutant emissions are likely to be negligible. This was due to a low level of vehicle movements on the local road network and an absence of sensitive receptors located in proximity to proposed area of construction and the proposed lay down and contractor vehicle routes.

The assessment included compilation of an emissions inventory of current atmospheric releases from the Bapco Refinery and calculated proposed BMP emissions based on technical specifications for the new processes. Atmospheric dispersion modelling was used to predict any changes in pollutant concentrations at receptor locations. The assessment concluded that implementation of the BMP would reduce SO_2, NO_2 and PM_{10} pollutant concentrations at the worst affected receptor locations. Some increases in NO_2 and PM_{10} concentrations were observed at locations with reduced PECs. Concentrations of CO at receptor locations were predicted to increase with implementation of the BMP, however the predicted PECs were less than 1% of the relevant air quality standard and therefore were considered to be negligible.

The significance of the impacts was assessed using IFC impact criteria. The assessment predicted that implementation of the BMP is unlikely to cause an exceedance of the national air quality standards or supplementary international guidelines. The PC of the refinery after implementation of the BMP was predicted to either meet the IFC criterion of 25% of the relevant air quality standard or show a reduction compared to the baseline situation. As such the impact of the BMP has been categorised as **not significant**. There are beneficial impacts, universally for concentrations of SO_2 and at the worst case receptors for NO_2 and PM_{10}.

With respect to GHGs, emissions from the BMP have been benchmarked and the requirement for annual public reporting of Scope 1 and Scope 2 GHG emissions during the operational phase has been identified.

6.8 References

(Bilfinger, 2014) Environmental and Social Impact Assessment Report, ALBA Potline (6) and Power Plant (PS 5) Expansion, 2014. Bilfinger.

(DEFRA, 2016) Greenhouse Gas Conversion Factor Repository, Government Conversion Factors for Company Reporting. Department for Environment, Food and Rural Affairs, 2016 available at URL: http://www.ukconversionfactorscarbonsmart.co.uk/, accessed on 04/05/2016.

(EA, 2011). H1 Annex F – Air Emissions, 2011. UK Environment Agency.

(EC, 2006) Integrated Pollution Prevention and Control. Reference Document on Best Available Techniques on Emissions from Storage, July 2006. European Commission.

(Equator Principles, 2013) Equator Principles III, 2013. Available at URL: http://www.equator-principles.com/index.php/ep3 accessed on 28.06.16

(EU, 2010) Directive 2010/75/EU of the European Parliament and of the Council of 24 November 2010 on Industrial Emissions (integrated pollution prevention and control).

(EU, 2014) Official Journal of the European Union. Commission Implementing Decision of 9 October 2014, reference C(2014)7155, establishing best available techniques (BAT) conclusions, under Directive 2010/75/EU of the European Parliament and of the Council on industrial emissions, for the refining of mineral oil and gas.

(European IPPC Bureau Joint Research Centre, 2014). Industrial Emissions Directive 2010/75/EU. Best Available Techniques (BAT) Reference Document in the Large Volume Organic Chemical Industry. Draft 1 (April 2014)

(European IPPC Bureau Joint Research Centre, 2014). Industrial Emissions Directive 2010/75/EU. Best Available Techniques (BAT) Reference Document in Large Combustion Plants. Draft 1, 2014.

(IAQM, 2005) Institute of Air Quality Management and Environmental Protection UK, 2005. Land-use Planning & Development Control: Planning for Air Quality.

(IAQM, 2014) Institute of Air Quality Management, 2014. Guidance on the Assessment of Dust from Demolition and Construction.

(IEA, 2012) CO_2 Emission Factors from Fuel Combustion (2012 edition). International Energy Agency

(IFC, 2007) International Finance Corporation (2007) General EHS Guidelines: Environmental – Air Emissions and Ambient Air Quality, April 30th 2007

(IFC, 2102) Performance Standard 3, Resource Efficiency and Pollution Prevention. International Finance Corporation, 2012.

(WHO, 2005) Air quality guidelines for particulate matter, ozone, nitrogen dioxide and sulfur dioxide, Global Update. World Health Organization, 2005.

(WRI, 2016). World Business Council on Sustainable Development, Greenhouse Gas Protocol, World Resources Institute, 2016 available at URL: http://www.ghgprotocol.org/

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Table 6.20 Summary of Air Quality Impacts

Impact	Nature of Impact (Permanent/ Temporary)	Significance (Minor/Moderate/Major) (Beneficial/Adverse/Negligible)	Mitigation / Enhancement Measures	Residual Impacts (Minor/Moderate/Major) (Beneficial/Adverse/Negligible)
Construction Phase				
Construction Phase Dust	Temporary	Negligible	Best practice dust mitigation measures implemented to minimise emissions	None
Construction Vehicle Emissions	Temporary	Negligible	Establishment of lay down area and routine haul routes away from residential areas	None
Operational Phase				
Point source (stack) Emissions	Permanent	Negligible for NO_2, PM_{10} and CO Beneficial for SO_2 concentrations	Stacks designed to allow adequate dispersion of pollutants into the atmosphere	Periodic monitoring of existing sources and BMP processes. Maintain emissions inventory to ensure that emissions remain within designed limits. Residual impact remains negligible for NO_2, PM_{10} and CO and beneficial for SO_2
Fugitive/ Evaporative Emissions	Permanent	Minor - Adverse	BMP processes designed in accordance with best practice to minimise losses	Fugitive/evaporative emissions minimised by adherence to site's existing environmental management/monitoring plan. Residual impact with BAT controls in place will be negligible.
Greenhouse Gas Emissions	Permanent	N/A – Good practice guidance followed	Annual, public reporting of emissions required for Scope 1 and Scope 2 GHG emissions.	N/A

7 SOIL AND GROUNDWATER

7.1 Introduction

Bapco Refinery has been operational since 1936. During that time the land has been in continuous industrial use. Given this long history of industrial use, soil and groundwater at site has been addressed as part of this ESIA.

In the case of the BMP, the main site for development was previously used to store Pitch. Ponds and has evidently been contaminated by this use. The main purpose of this section of the ESIA is to assess the residual contamination present on the Pitch Ponds and to identify how the land will be remediated to make it suitable for its intended use as the site for the BMP. The assessment will also consider best practice measures for the management of contamination issues in respect of BMP development on the Refinery site and Sitra Tank Farm sites, but will focus on the Pitch Ponds. This is because understanding and mitigation of the contamination on the Pitch Ponds is essential to unlocking the redevelopment of the Pitch Ponds for the BMP.

The potential impacts on soil and groundwater from use and storage of chemicals (and fuels) during BMP construction and operation are discussed in the ESIA section on Chemicals (**Section 16**).

7.2 Legislation and Guidance

7.2.1 Legislation

There are no specific environmental regulations in Bahrain in respect of land contamination; however, environmental issues in Bahrain are mainly dealt with under Legislative Decree No. 21 of 1996 in Respect of the Environment (Law No. 21).

The main objective of Law No. 21 is set out in Article 1, which provides for the following:

"….protecting the environment from sources and causes of pollution and curbing its deterioration through the formation of the required plans and policies for its protection against harmful effects….which may result in causing damage to human health, agricultural products, marine and wildlife, other natural resources, the climate, etc."

Hence there is a general requirement for protection of the environment including soil, geology and groundwater resources.

7.2.2 Guidance

7.2.2.1 Model Procedures for the Management of Contaminated Land (CLR 11), UK Environment Agency 2005

The main guidance used to formulate the assessment is Model Procedures for the Management of Contaminated Land (CLR 11) UK Environment Agency 2005. The document provides an overview of the approach for the management of contaminated land using a phased approach.

Three phases of increasing detailed analysis are identified:

i. Phase 1 – review of desk based information, e.g. historic maps, etc.;
ii. Phase 2 – Assessment of site investigation results against international standards for land quality;
iii. Phase 3 – Detailed Quantitative Risk Assessment (DQRA) use of site specific modelling to develop more realistic models of source – pathways – Targets.

Each phase is progressed from one to the other until the contamination is identified as not significant (i.e. it is risked out) or the contamination is identified as significant and remediation is required.

The document also recommends the use of the Source – Pathway – Target (S-P-T) methodology to analyze contaminated land where:

i. Sources – contamination that may be present based on the previous site investigations or new contamination that may be introduced by the proposed project or its construction.
ii. Pathways – the means by which contamination may migrate.
iii. Targets – environmental receptors including occupants, workers, geological and hydrogeological receptors.

Where a source – pathway-target linkage is present then it is likely that contamination is having a significant environmental impact.

Where a source – pathway – target linkage is not present any contamination is not considered to be having a significant environmental impact.

7.2.2.2 World Bank, Environmental Health and Safety (EHS) Guidelines, 2007 (World Bank 2007)

Section 1.8 of the general EHS guidelines addresses contaminated land. The document identifies an approach to the management of contaminated land that is very similar to that identified by the UK Environment Agency. It recommends development of a source-pathway-target model and a phased approach to risk assessment and remediation. It also identifies risk reduction measures (remediation) as interim for situations where there are immediate EHS risks and permanent as a longer term approach where there are no immediate EHS concerns.

7.3 Baseline

7.3.1 Pitch Ponds Site Investigation

The Pitch Ponds are the main site of the BMP. To determine the condition of the site and the implications for development of the BMP, a geo-environmental site investigation was undertaken on the Pitch Ponds site in 2014. A copy of the site investigation report is included as **Appendix 7A**. The report has been modified from the original to remove: financial information; superseded geotechnical recommendations and; updates on the site conditions since 2014.

The site investigation was carried out using a phased, risk-based approach approach consistent with CLR 11, UK Environment Agency 2005 and World Bank EHS Guidelines, 2007.

The following sections provide a summary of the findings.

7.3.1.1 Pitch Ponds Site History

The Pitch Ponds comprises an open area of low-lying flat land located to the south west of the Refinery. The Pitch Ponds site has previously been used as an area for the storage of pitch, a refinery byproduct. The majority of the pitch was deposited during World War II between 1941 and 1945 when the pitch was produced by the refinery but had no immediate market. It is believed some additional pitch was added after this time. It was estimated that approximately 1,000,000 m^3 of pitch was present on the site.

In the late 1990s AGAS obtained a lease on the Pitch Ponds from Bapco and established a business to recover the pitch and to put it to beneficial use as a component of lubricating oil. Since that time AGAS have removed the vast majority of the pitch from the site. There are residual pitch ponds in the western part of the site. AGAS are continuing to recover the remaining pitch until completion and then the facility will be decommissioned and demolished. This work will be undertaken by AGAS and is not part of the BMP. When the land is returned to Bapco, it will be used for laydown and temporary construction facilities during the construction phase of the BMP and it will be in similar condition to the remainder of the Pitch Ponds site.

7.3.1.2 Pitch Ponds Geology and Hydrogeology

From the site investigation, the ground was confirmed to consist of 3 m-6.5 m of silty sand overlying permeable, Khobar limestone. Groundwater is present at approximately 1.5 to 2 m below ground level (at approximately sea level). The recorded groundwater gradient was almost flat but with a very slight gradient from south east to north west.

The Khobar limestone comprises a groundwater resource known as “Aquifer B”. The aquifer is approximately 30-40 m thick and within parts of Bahrain, the aquifer is an important groundwater resource and is abstracted for use in residential supply (although it is too saline for use as drinking water without further treatment). However, there are no known abstraction points within the vicinity of the Refinery. The Refinery itself does operates three groundwater abstraction wells but these draw water from Aquifer C (approximately 5,450 m^3/day) which is located at a depth of approximately 150 m and which is discontinuous with Aquifer B.

7.3.1.3 Soil Conditions

The soil at the Pitch Ponds is contaminated with residual pitch. The residual pitch comprises a viscous liquid mixed with the shallow silty sand. The pitch penetrates the majority of the silty sand superficial deposits. When mixed with sand the pitch forms a solid to semi-solid mass.

The pitch comprises mainly high chain length, aliphatic and aromatic hydrocarbons. Concentrations of poly aromatic hydrocarbons (PAH) are generally low as are the concentrations of other organic and inorganic contaminants.

7.3.1.4 Other Soil Conditions

There is also a potential area of soil contamination in the south west of the pitch ponds where oil contaminated waste soil was deposited by AGAS. This material may pose a risk to groundwater resources (i.e. Aquifer B) through dissolution and dispersion. The material was removed in 2015 by AGAS but there was no remediation validation survey to confirm that the contamination was fully removed. It is possible that some of this hydrocarbon contaminated soil remains.

7.3.1.5 Pitch Ponds Groundwater Conditions

Groundwater quality seems to be little affected by the pitch (its components are, generally, highly insoluble).

An area of groundwater contamination is present in the north western part of the Pitch Ponds which comprises an area where Light Non Aqueous Phase (LNAPL) is present (BH1056). LNAPL is free phase hydrocarbon floating on groundwater. Its thickness was measured as 0.37 m in 2014. Similar LNAPL was identified by ENSR in 1996 at the same general location. The LNAPL has been tentatively identified as weathered diesel. Groundwater in the same borehole was identified to be contaminated with low levels of dissolved benzene, toluene, ethyl benzene xylenes (BTEX) and MTBE consistent with unleaded petrol contamination.

Moderate levels of groundwater contamination with diesel and lubricating oil range hydrocarbons was also identified at a borehole located adjacent to the AGAS facility (BH1060).

A monitoring well positioned between the sea and the former Pitch Ponds showed no evidence of groundwater contamination.

7.3.2 Refinery and Sitra Tank Farm – Soil and Groundwater Conditions

It is expected that there will evidence of soil and groundwater contamination at the main Refinery site and Sitra Tank Farm. These sites do not comprise the main site for the BMP and so have not been addressed in detail in this assessment other than to consider the general site conditions expected and the general approach to management of any contaminated soil and groundwater. In essence whilst these sites may be contaminated and this contamination will need to managed, it is not central to the feasibility of the project.

Further assessment of the soil and groundwater contamination on the Refinery and Sitra sites will be undertaken as part of the EPC Phase of the contract.

7.4 Assessment Methodology

7.4.1 ESIA Significance Criteria

The findings of the contamination assessment have been classified using the following impact assessment five point scale:(i) Major Beneficial, (ii) Minor Beneficial (iii) Negligible, (iv) Minor Adverse, (v) Major Adverse. These classifications have been applied both pre and post mitigation. The Significance Criteria have also been applied to both construction and operational scenarios.

Table 7.1 shows descriptions of risk impact significance classifications for each scenario given above. **Table 7.1** refers to the amenity value of a resource. The amenity value of a natural resource is its capability to be used for a certain purpose, e.g. groundwater being used for abstraction of a drinking water supply, use of land for agriculture. Should the project reduce the amenity value of a resource this will be considered a major adverse impact. For example, contamination of groundwater so that it is no longer suitable for use as drinking water. Where the project is expected to release pollution to a resource but it does not affect its amenity value the impact will be considered a minor adverse impact.

Table 7.1 Soil and Groundwater Impact Assessment Significance Criteria

Scenario	Major Adverse	Minor Adverse	Negligible	Minor Beneficial	Major Beneficial
Construction impacts	Construction workers will be exposed to unacceptably high concentrations of contamination. Construction work may introduce new pathways which would expose environmental targets to unacceptably high concentrations of contamination causing pollution (exceedance of environmental standards).	Construction workers may be exposed to elevated concentrations of contamination. Construction work may introduce new temporary pathways which could expose environmental targets to increased concentrations of contamination.	Adverse environmental impacts to construction workers mitigated through the use of appropriate personal protective equipment. Use of mitigation measures to eliminate potential introduction of contamination exposure pathways. Appropriate environmental management and monitoring to mitigate contamination impacts.	Remediation of contamination.	Remediation of significant contamination.
Impacts of new development	The new development is likely to impact the quality of soil and groundwater through the release of pollutants and this would reduce the amenity value of a natural resource (e.g. aquifer) and prevent it being used for its intended or suitable purpose.	The new development may impact the quality of soil and groundwater through minor pollution but would not reduce the amenity value of a natural resource.	The new development is not expected to reduce the amenity value of a natural resource through the release of pollutants to soil or groundwater.	n/a	n/a

7.5 Impact Assessment

7.5.1 Pitch Ponds Soil Conditions

The pitch contaminated soil may represent a fire hazard where the concentration of pitch is greater than 20%. Pitch contaminated soil also represents a nuisance hazard in that it sticks to surfaces and materials and is hard to remove. Quantitative human health risk assessment has identified that benzo (a) pyrene (BaP - a PAH) is the key contaminant present in pitch and a maximum safe level for long term exposure of workers is 14 mg/kg. Much of the pitch contains BaP at greater than this concentration and therefore, remediation will be required before the Pitch Ponds site can be developed for the BMP. For these reasons the presence of pitch is considered a potential major adverse impact that will require mitigation.

7.5.2 Pitch Ponds Groundwater Conditions

Waste soil deposited in the south western part of the pitch ponds site was removed in 2015 but the process was not witnessed or validated and it is unclear if any residual contamination remains. Any residual contaminated soil would pose an on-going minor adverse impact to groundwater resources.

The LNAPL contamination identified in the north east of the site in BH1056 is not considered mobile. Preliminary evidence indicates that it has probably not migrated significantly in 18 years. This is consistent with the observation of a practically flat groundwater gradient. The LNAPL, weathered diesel, will be dissolving and impacting local groundwater quality within Aquifer B. Aquifer B does comprise a nationally important groundwater resource, but within this region of Bahrain, which is predominantly industrial, it is not exploited and there is no reasonable likelihood of its exploitation in the foreseeable future. Therefore the presence of LNAPL is considered a minor adverse impact.

The BTEX and related VOC contamination identified in BH1056 is considered a minor adverse impact. Technip consider that there is a potential risk of ingress of VOC vapours into built structures on the Pitch Ponds site.

The dissolved hydrocarbon contamination identified in BH1060 is considered a minor adverse impact. The contamination is considered moderate and as previously stated the local groundwater does not comprise a significant amenity resource.

There is no evidence that any of the groundwater contamination is impacting the marine environment (this will be confirmed by the groundwater monitoring plan).

7.6 Mitigation and Monitoring

7.6.1 Pitch Ponds Soil Conditions

Removal or remediation of the pitch contaminated soil is not technically or economically viable due to the quantity of soil impacted. The pitch does not represent a threat to the wider environment as it is not mobile in soil or groundwater. Capping the site with clean soil has been identified as the most viable remediation option.

Using a UK risk assessment model, in respect of the protection of the health of future site occupiers, a 442 mm capping layer of clean fill material has been calculated to comprise adequate mitigation. As part of the BMP engineering design it is intended to increase the site levels by approximately 3 m average using dune sand fill. This greatly exceeds the minimum capping requirement to protect human health. Remediation of the Pitch Ponds site and bringing it back into beneficial use would be a major beneficial impact of the BMP.

7.6.2 Pitch Ponds Groundwater Conditions

The area where oily waste soil was deposited by AGAS in the south west of the Pitch Ponds should be subject to a further site investigation to confirm or otherwise that the contaminated soil was removed. This would reduce the residual impact significance from minor adverse to negligible.

In the north western part of the site, in the vicinity of BH1056 (containing LNAPL and VOC contamination) it is intended to locate temporary offices for the BMP construction site staff. The area will be capped with clean fill and a concrete slab. Technip has recommended that the slab incorporates an impermeable membrane to prevent any possibility for intrusion of hydrocarbon vapours into buildings. Technip has also recommended this approach for office buildings on the whole of the pitch ponds site as a precautionary measure. The residual environmental impact will be negligible with respect to the BMP.

The groundwater contamination in BH1056 and BH1060 requires further precautionary monitoring. A groundwater monitoring program should be developed during the EPC Phase of the project.

7.6.3 Construction - General Requirements

7.6.3.1 Management of Contaminated Soils

For all construction activities likely to give rise to excess contaminated soil, planning of the activity will include waste management planning so that all contaminated soil is treated or disposed of as part of the activity.

Contaminated soils excavated during piling will be kept separate from clean soils. Where needed sheeting will be placed on the ground to prevent contaminated pile arisings impacting clean fill material.

It is expected that pitch contaminated soils excavated during piling works will be able to be reused as fill material within the Pitch Ponds site, provided that it is capped with clean fill so that it is remediated to a similar standard to the rest of the site.

For all other contaminated soils they will be temporarily stored on-site and treated within the Bapco hazardous waste management program which will include methods for the on-site remediation of hydrocarbon contaminated soils.

7.6.3.2 Construction Workers

Construction site workers, particularly those involved in groundworks have the potential to come into contact with contaminated soils. Therefore precautions should be taken to avoid exposure of workers to contamination. Where there is potential for workers to be exposed to contamination the following precautions should be taken:

1. All excavation works should follow a permit to work system.
2. A risk assessment should be undertaken prior to starting excavation work to identify the potential for workers to be exposed to contamination and how their exposure will be mitigated.
3. Adequate personal protective equipment (PPE) will be provided to all groundworkers as needed. This will include gloves, respirators, overalls and personal exposure monitoring for VOCs.
4. All groundworkers should be provided with hygiene facilities to change from site work wear, shower and change into their own clothes.
5. Overalls should be of the disposable type or washed regularly.
6. No food or drink should be consumed at the work site and no food or drink should be consumed without passing out of the site through the hygiene facility (this excludes access to water at site which is essential during the summer period).

7.6.4 Groundwater Monitoring

It is recommended that the BMP undertake a long-term program of groundwater monitoring. The monitoring is recommended to provide a means of identifying any impact the BMP may have on groundwater quality during its operation. This would allow any issues to be identified at an early stage and allow an appropriate response to be rapidly developed.

A groundwater monitoring program will be developed during the EPC Phase of the project.

7.6.5 Vapour Intrusion Barriers

In line with Technip's recommendation to incorporate vapour barriers within ground slabs for occupied buildings within the pitch ponds, it is recommended to extend this to all occupied buildings within the BMP, as a precautionary measure. Vapour barriers should be incorporated into the slab to protect the membrane from possible direct contact with contaminated soils which, in the long-term could damage the membrane.

7.7 Summary

Remediation of the Pitch Ponds site is vital to the implementation of the BMP. The identified remediation strategy of infill and capping the site with clean fill will make the site suitable for its intended use and will allow this contaminated site to be brought back into beneficial use.

Table 7.2 shows a summary of the soil and groundwater issues. In most cases, suitable management and a precautionary approach can reduce the predicted impacts to a negligible level.

Table 7.2 Summary of Soil and Groundwater Impacts

Impact	Significance (Minor, Major Beneficial / Adverse or Negligible)	Mitigation Measures	Residual Impacts (Minor, Major Beneficial / Adverse or Negligible)
Construction			
Pitch Ponds - Presence of residual pitch on pitch ponds	Major Adverse	Capping with +3m of clean fill	Major Beneficial
Pitch Ponds - Waste oil contaminated soil – no validation of earlier remediation	Minor Adverse	Undertake remediation validation site investigation, remove any significant contamination found	Negligible
Pitch Ponds - Presence of LNAPL in BH1056 and dissolved hydrocarbon contamination in BH1060	Minor Adverse	Groundwater monitoring – Develop and implement a groundwater monitoring plan.	Minor Adverse
Pitch Ponds / All BMP - VOC vapour intrusion BH1056 into built structures	Minor Adverse	Incorporate impermeable vapour barrier into ground slab of buildings. Extended to all occupied BMP buildings as a precautionary measure.	Negligible
All BMP – Contaminated soils	N/A – Good practice guidance	Keep contaminated pile arisings separate from clean soil. Reuse or remediate contaminated soils within Bapco facilities.	N/A
All BMP – Construction Workers, protection of health	N/A – Good practice guidance	Implement good practice measures to reduce worker exposure to contaminant	N/A
All BMP – Groundwater contamination	N/A – Good practice guidance	Groundwater monitoring – Develop and implement a groundwater monitoring plan.	N/A
All BMP sites – Update Contamination Assessment	N/A – Good practice guidance	Update the contamination assessment during the EPC Phase as the BMP design develops	N/A
Operation			

Impact	Significance (Minor, Major Beneficial / Adverse or Negligible)	Mitigation Measures	Residual Impacts (Minor, Major Beneficial / Adverse or Negligible)
All BMP – Groundwater contamination	N/A – Good practice guidance	Groundwater monitoring – Develop and implement a groundwater monitoring plan.	N/A

7.8 References

(EACS, 2016) Geo-environmental Site Investigation Report, Bapco Pitch Ponds, BMP ESIA Version. Environment Arabia Consultancy Services. May 2016.

(ENSR, 1996) ENSR Pitch Pond Characterization Study 1996

(GDC, 1980) Groundwater Development Consultants (GDC), 1980. Umm Er Radhuma Study, Bahrain Assignment. Ministry of Works and Agriculture.

8 NOISE

8.1 Introduction

This chapter of the ESIA considers the likely effects of the BMP in terms of noise and vibration. This section describes the assessment methodology; the baseline conditions currently existing at the site and surroundings; the likely environmental effects during the construction and operational phases of the BMP, the mitigation measures required to prevent, reduce or offset any adverse effects; and the likely residual effects after these measures have been employed.

8.2 Legislation and Guidance

8.2.1 Construction Noise

8.2.1.1 International Standards

Construction noise effects have been assessed using the methodology within BS 5228-1&2:2009+A1:2014 Code of Practice for Noise and Vibration Control on Construction and Open Sites (British Standards Institute (BSI), 2014A and B). This standard represents the generally accepted industry best practice for controlling noise and vibration from works of construction, excavation and demolition. Annex F of this Standard also contains a methodology for estimating noise levels that can arise from various construction techniques as well as recognised methods of mitigating excessive noise levels. BS 5228 gives several examples of acceptable limits for construction noise. The most simplistic being based upon the exceedance of fixed noise limits and states in paragraph E.2:

“Noise from construction and demolition sites should not exceed the level at which conversation in the nearest building would be difficult with the windows shut”.

Paragraph E.2 goes on to state:

“Noise levels, between say 07.00 and 19.00 hours, outside the nearest window of the occupied room closest to the site boundary should not exceed: 70 decibels (dBA) in rural, suburban areas away from main road traffic and industrial noise or 75 decibels (dBA) in urban areas near main roads in heavy industrial areas. These limits are for daytime working outside living rooms and offices”.

To provide variable noise limits for the day, evening and night-time periods the ‘ABC method’ from BS5228 has been informally adopted for Bahrain, the details of which are summarized in **Table 8.1** below. In order to place a receptor in category A, B or C, the existing noise level is rounded to the nearest 5 dB and compared to the levels in Category A.

Table 8.1 Construction Noise Limits (Adapted for Bahrain)

Assessment Category and Threshold Value Period (L_{Aeq})	Threshold Value, dB		
	Category A [A)]	Category B [B)]	Category C [C)]
Night time (23.00 to 07.00)	45	50	55
Evenings (19.00-23.00) and Daytime Friday	55	60	65
Daytime (07.00 – 19.00)	65	70	75

[A)] Category A: threshold values to use when ambient noise levels (when rounded to the nearest 5 dB) are less than these values.

[B)] Category B: threshold values to use when ambient noise levels (when rounded to the nearest 5 dB) are the same as category A values.

[C)] Category C: threshold values to use when ambient noise levels (when rounded to the nearest 5 dB) are higher than category A values.

It is worth noting that the purpose of the target construction noise criteria is to control the impact of construction noise insofar as is reasonably practicable, whilst recognising that it is unrealistic for developments of this nature to be constructed without causing some degree of disturbance in the locality.

8.2.1.2 Bahrain Noise Guidelines

The Bahrain guidelines for noise, presented in **Table 8.2** below, provide noise limits for different area types for day, evening and night time periods. The day and night time noise limits for residential areas are the same as the World Health Organisation (WHO) recommended ambient noise levels.

Table 8.2 Bahrain Noise Guideline Values

Location of Facility	Maximum Allowable Noise Limit (dB $L_{Aeq,T}$)
Residential Area A	55
Residential Area B	50
Residential Area C	45
Residential Area with some Commercial Activity A	60
Residential Area with some Commercial Activity B	55
Residential Area with some Commercial Activity C	50
Commercial Area A	70
Commercial Area B	70
Commercial Area C	70

A Acceptable daytime noise levels from 7.00-16.00 hours

B Acceptable evening noise levels from 16.00-23.00 hours

C Acceptable night time noise levels from 23.00-7.00 hours

8.2.1.3 WHO and World Bank Guidelines

The international perspective is set by the WHO document ‘Guidelines for Community Noise’ in 1999 (WHO, 1999). World Bank EHS Guidelines, General EHS Guidelines, 2007 (World Bank, 2007), provide simplified noise guidelines based those set by WHO.

Table 1, of the WHO Guidelines provide a series of recommended noise exposure levels as summarised in **Table 8.3** below. This standard provides a precautionary approach and must be used appropriately.

The WHO guidelines provide internal noise levels in the night-time period that indicate the threshold of sleep disturbance. The WHO guidelines also state that at night, sound pressure levels at the outside facades of the living spaces should not exceed 45 dB L_{Aeq} and 60 dB L_{Amax} so that people may sleep with bedroom windows open. These values have been obtained by assuming that the reduction from outside to inside with the windows partly open is 15 dB.

Table 8.3 WHO Guideline Values for Community Noise in Specific Environments

Specific Environment	Critical Health Effect(s)	L_{Aeq} dB	Time Base Hours	$L_{Amax,fast}$ dB
Outdoor living areas	Serious annoyance, daytime and evening	55	16	-
	Moderate annoyance, daytime and evening	50	16	
Dwelling, indoors	Speech intelligibility & moderate annoyance	35	16	-
Inside Bedrooms	Sleep disturbance, night-time	30	8	45

8.2.2 Road Traffic Noise

The noise effects of road traffic are predicted using the guidance contained in ‘Calculation of Road Traffic Noise (CRTN), UK Department of Transport (DoT), 1988’ (DoT, 1988) and consider the noise levels against criterion provided in ‘The Noise Insulation Regulations 1975’ (UK Government (Gov.), 1975) and ‘The Noise Insulation (Amendment) Regulations 1988’ (UK Gov., 1988).

The impact of any changes in road traffic noise levels has been considered against the principles and guidance presented within the Design Manual for Roads and Bridges (DMRB) Part 7 HD213/11 Noise and Vibration, UK Highways Agency, 2011 (Highways Agency, 2011). DMRB states that:

“The impact of a project at any location can be reported in terms of changes in absolute noise level. In the UK the standard index used for traffic noise is the $L_{A10,18hr}$ level, which is quoted in decibels”.

DMRB presents impact significance matrices for assessing the magnitude of changes in noise level for the short and long term and can be used as criteria for assessing the impact of any changes in road traffic noise levels, as shown in **Tables 8.4** and **8.5** respectively.

Table 8.4 **Semantic Descriptors for Traffic Noise in the Short Term**

Change in Noise Level $L_{A10,18\ hr}$ dB	Magnitude of Impact
0	No Change
0.1 to 0.9	Negligible
1 to 2.9	Minor
3 to 4.9	Moderate
5+	Major

Table 8.5 **Semantic Descriptors for Traffic Noise in the Long Term**

Change in Noise Level $L_{A10,18\ hr}$ dB	Magnitude of Impact
0	No Change
0.1 to 2.9	Negligible
3 to 4.9	Minor
5 to 9.9	Moderate
10+	Major

Table 8.4 is concerned with the short-term difference, which would be considered during the six months following the completion of construction, thereafter, **Table 8.5** applies. The criteria in **Table 8.4** above reflect key benchmarks of human response to changes in noise level. For example, a 3 dB change is generally taken to be the smallest change perceptible in the human ear and a 10 dB change is heard as a doubling or halving of the loudness of a source. The 5 dB category has been included as it provides greater definition of the assessment of changes in noise level.

8.2.3 Internal Noise for Residential

BS 8233:2014 'Sound insulation and noise reduction for buildings - Code of Practice' (BSI, 2014) recommends a design standard for bedrooms to be 30 dB L_{Aeq} – night-time and 35 dB – day-time, and night-time individual noise events should not normally exceed 45 dB L_{Amax} as a reasonable internal standard.

With respect to external noise levels, reference is made to WHO guidance that states "general daytime outdoor noise levels of less than 50-55 dB L_{Aeq} are desirable to prevent any significant community annoyance". Application of a similar limit to external garden areas used for amenity purposes would, therefore, prevent significant community annoyance. In this case, the level of 50-55 dB(A) is a free-field value, i.e. it does not include façade reflection factors.

However, in considering the application of an outdoor criterion of 50-55 dB L_{Aeq}, which is derived from the earlier World Health Organisation (WHO) guidance, it is important to take account of the feasibility of achieving such a level. A recent UK National Physics Laboratory (NPL) Report entitled 'Health Effect-Based Noise Assessment Methods: A Review and Feasibility Study' (NPL Report CMAM 16, 1998) concluded the following:

"Perhaps the main weaknesses of both WHO-inspired documents is that they fail to consider the practicality of actually being able to achieve any of the stated guideline

values. … We know from the most recent national survey of noise exposure carried out in England and Wales (Sargent 93) that around 56% of the population are exposed to daytime noise levels exceeding 55 L_{Aeq} and that around 65% are exposed to night-time noise levels exceeding 45 L_{Aeq} (as measured outside the house in each case). …. The percentages exposed above the WHO guideline values could not be significantly reduced without drastic action to virtually eliminate road traffic noise and other forms of transportation noise (including public transport) from the vicinity of houses. The social and economic consequences of such action would be likely to be far greater than any environmental advantages of reducing the proportion of the population annoyed by noise. In addition, there is no evidence that anything other than a small minority of the population exposed at such noise levels find them to be particularly onerous in the context of their daily lives."

8.2.4 Vibration

Structural damage from vibration is assessed in terms of peak particle velocity (PPV). BS 7385:1993 'Evaluation and Measurement for Vibration in Buildings' Part 2, Guide to Damage Levels from Ground-Borne Vibration (BSI, 1993), gives guidance as to the maximum levels which should not be exceeded to avoid structural damage occurring to various construction types. These levels are reproduced in **Table 8.6** below.

Table 8.6 Transient Vibration Guide Values for Cosmetic Damage

Type of Building	Peak Component Particle Velocity in Frequency Range of Predominant Pulse	
	4 Hz to 15 Hz	**15 Hz and above**
Reinforced or framed structures Industrial and heavy commercial buildings	50 mm/s at 4 Hz and above	
Unreinforced or light framed structures Residential or light commercial type buildings	15 mm/s at 4Hz increasing to 20 mm/s at 15 Hz	20 mm/s at 15 Hz increasing to 50 mm/s at 40 Hz and above

Human perception to vibration is considered within BS6472-1:2008 (BSI, 2008) and vibration levels that represent satisfactory magnitudes of building vibration with respect to human response are provided in Section 6 of the Standard in terms of Vibration Dose Values (VDVs).

Table 8.7 below summarises a range of vibration levels in terms of VDV, and the associated human perception. More specifically, it indicates various degrees of 'adverse comment' expected in residential buildings due to vibration during the daytime and night-time. BS 6472 introduced the concept of VDV, which is a measure of the amount of vibration which is experienced over a given period. The standard contains VDV levels which are considered acceptable for daytime or night time periods and are as follows.

Table 8.7 Indication of Response to Vibration in Terms of VDV ($m/s^{1.75}$)

Time Period	Low Probability of Adverse Comment VDV ($m/s^{1.75}$)	Adverse Comment Possible VDV ($m/s^{1.75}$)	Adverse Comment Probable VDV ($m/s^{1.75}$)
16hr day in residential building	0.2 to 0.4	0.4 to 0.8	0.8 to 1.6
8hr night in residential building	0.1 to 0.2	0.2 to 0.4	0.4 to 0.8

8.3 Assessment Methodology

8.3.1 Sensitive Receptors

Potentially sensitive receptors with respect to noise were identified as part of the land use survey of the project undertaken during the scoping phase of the project. The Bahrain Noise Guidelines designate the receptors as being in a residential area with some commercial activity as shown in **Table 8.2**. The following receptors were identified:

N1 Quiet residential area
N2 Residential area adjacent to busy road
N3 Labour accommodation block (new, unoccupied)
N4 Adjacent to accommodation blocks that are under construction
N5 Adjacent to accommodation blocks
N6 Open area to become BMP labour camp and laydown area
N7 Quiet area adjacent to Bapco fence line, near to proposed BMP labour camps

These receptors are shown on **Figure 8.1**. Baseline noise monitoring was undertaken at each of these locations.

8.3.2 Site Preparation / Construction

It is understood that construction activities will include infill to a depth of 3m and there will be associated HGV movements on the dual carriageway as well as on-site construction activities. In order to determine the likely impact of noise during construction of the BMP, noise predictions have been carried out in accordance with the procedures presented in BS 5228. The prediction method described in BS 5228 involves taking the source noise level of each item of plant and correcting it for (i) distance effects between source and receiver (ii) percentage operating time of the plant; (iii) barrier attenuation effects; (iv) ground absorption; and (v) facade corrections.

Title: **Baseline Noise Survey Locations**		Client: Bapco Technip
Project: Bapco Modernization Program		
Date: May 2016	Figure No.: 8.1	Consultant: Environment Arabia
Datum: WGS 84 - UTM 39N	Scale: 1:40,000 (A4)	

CN:\Bapco Modernisation Plan\mxd\8.1 baseline noise survey locs.mxd

8.3.3 Operational Noise

The noise from plant and machinery at the BMP has been predicted by Technip S.p.A. at the nearest noise sensitive receptors to the BMP. Technip have calculated the noise levels at Receptors N1 to N7 based on noise from the new process units, which consist of specific noise sources (e.g. pumps, compressors) on the main items of BMP plant: 2HCU; 1SGP; 2SGP; 7CDU; 7VDU; 3HDU; 1HRU; 1RHCU; indirect cooling water system; and sulphur block. Technip have produced a noise emission modelling report for the BMP. The report is included as **Appendix 8A**.

8.3.4 Significance Criteria

The significance of the impact of predicted changes in noise level as a result of the BMP have been described using the qualitative criteria identified in **Table 8.8.** The construction noise effects consider the guidance and target noise levels provided by the ABC methodology in BS5228 and a minor adverse effect correlates with a 3 dB exceedance of the day, evening or night noise targets, a moderate effect is provided by a 5 dB or greater exceedance and a major effect is provided by a 10 dB or greater exceedance. With respect to traffic noise, the quantitative descriptors provided by the CRTN methodology have been used to determine the impact magnitude and significance. Noise from plant and machinery associated with the operational BMP is considered against the Bahrain Noise Guidelines values for residential areas and an exceedance of up to 3 dB provides a minor adverse effect and above 5 dB is considered to be a moderate adverse effect.

Table 8.8 Impact Significance

Significance	Impact Characteristic
Major Beneficial	The impact is large scale, giving rise to a significant gain to the environment.
Moderate Beneficial	The impact would provide a positive gain to the environment.
Minor Beneficial	The impact is small and would have a slight benefit to the environment.
Negligible	Either no impact or the impact is neutral (neither adverse nor beneficial).
Minor Adverse	The impact is small and of little concern; it is undesirable but acceptable).
Moderate Adverse	The impact gives rise to some concern but is likely to be tolerable in the short-term (e.g. during the construction phase) or would require a value judgment as to its acceptability.
Major Adverse	The impact is large scale, giving rise to great concern; it should be considered unacceptable and requires mitigating, compensating or a significant change to the development if no alternative is available. If no mitigation is possible, then the impact would require a value judgment as to its acceptability.

8.4 Environmental Baseline

8.4.1 Noise Survey

Baseline conditions have been established from short-term day and night-time noise monitoring at the nearest noise sensitive receptors identified (N1-N7 shown on **Figure 8.1**). A summary of the baseline noise levels measured at these locations is shown in **Table 8.9** below. The full details of the baseline noise measurement survey are included in **Appendix 8B.**

Table 8.9 Baseline Noise Measurement Summary

Location	Noise Indices	Noise Level, dB(A)		
		Daytime	Evening	Night
N1	$L_{eq,T}$	57.4	52.6	49.9
	$L_{max,f}$	71.9	62.1	55.9
	$L_{10,T}$	59.6	53.9	51.7
	$L_{90,T}$	54.2	51.0	48.9
N2	$L_{eq,T}$	67.8	57.0	58.6
	$L_{max,f}$	83.7	67.7	76.0
	$L_{10,T}$	70.7	58.0	62.2
	$L_{90,T}$	61.0	55.0	51.2
N3	$L_{eq,T}$	60.6	56.8	53.0
	$L_{max,f}$	73.8	83.7	57.5
	$L_{10,T}$	62.9	55.6	54.7
	$L_{90,T}$	57.0	52.6	50.4
N4	$L_{eq,T}$	65.1	60.8	58.9
	$L_{max,f}$	80.7	70.1	67.0
	$L_{10,T}$	67.0	62.4	61.2
	$L_{90,T}$	61.3	58.8	55.8
N5	$L_{eq,T}$	52.6	52.0	61.6
	$L_{max,f}$	62.2	66.2	78.6
	$L_{10,T}$	54.5	53.3	63.2
	$L_{90,T}$	48.8	50.3	52.4
N6	$L_{eq,T}$	55.8	50.7	53.7
	$L_{max,f}$	74.3	61.7	60.2
	$L_{10,T}$	55.5	51.8	54.8
	$L_{90,T}$	51.1	49.2	52.6
N7	$L_{eq,T}$	61.7	54.1	54.5
	$L_{max,f}$	78.4	64.2	64.5
	$L_{10,T}$	61.2	55.7	55.8
	$L_{90,T}$	52.5	52.3	53.1

8.5 Assessment of Impacts

8.5.1 Construction Phase

The construction phase of the BMP will involve a number of activities that could produce noise. These include infill to a depth of 3m, site preparation, general site activities and construction traffic.

The construction noise levels have been predicted based on the source noise data provided in BS5228. The noise levels used for the construction noise assessment and the estimated percentage on-times for each activity are shown in **Table 8.10**, below.

Table 8.10 Construction Source Noise Levels from BS5228

Site Clearance	**Noise Level at 10m $L_{Aeq,T}$ dB**	**% on-time**
Tracked Excavator (2-off)	78	50
Wheeled backhoe	68	50
Dozer	75	50
Diesel generator (6.5 kva)	66	100
Infill to Depth of 3m and site preparation	**Noise Level at 10m $L_{Aeq,T}$ dB**	**% on-time**
Dozer	75	50
Tracked Excavator (2-off)	78	50
Roller	73	50
Asphalt paver (+ tipper lorry)	75	50
Vibratory roller	75	50
Diesel generator (6.5 kva)	66	100
General Site Activities	**Noise Level at 10m $L_{Aeq,T}$ dB**	**% on-time**
Crawler Crane	82	50
Tower Crane	76	50
Bored Piling	83	50
Manual tools, cutting and grinding steel	80	75
Concrete batching and pouring	75	50
Welding steel	73	50
Construction Vehicles	**Noise Level at 10m $L_{Aeq,T}$ dB**	**% on-time**
Delivery of materials	76	10/hour

8.5.2 Construction Noise Predictions

The construction noise levels have been predicted at the nearest receptor locations to provide an indication of the noise levels during construction. The predicted noise levels are based on the source noise levels and percentage on-times from **Table 8.10** and are shown in **Table 8.11**, below.

Table 8.11 Predicted Construction Noise Levels at Nearest Receptors

Receptor Locations	Construction Activity	Predicted Noise Level $L_{Aeq,T}$ dB
N1	Site Clearance	38
	Infill to Depth of 3m and site preparation	38
	General Site Activities	42
	Construction Vehicle Movements	36
N2	Site Clearance	39
	Infill to Depth of 3m and site preparation	42
	General Site Activities	44
	Construction Vehicle Movements	38
N3	Site Clearance	43
	Infill to Depth of 3m and site preparation	49
	General Site Activities	47
	Construction Vehicle Movements	43
N4	Site Clearance	53
	Infill to Depth of 3m and site preparation	54
	General Site Activities	58
	Construction Vehicle Movements	47*
N5	Site Clearance	62
	Infill to Depth of 3m and site preparation	63
	General Site Activities	67
	Construction Vehicle Movements	49
N6	Site Clearance	61
	Infill to Depth of 3m and site preparation	62
	General Site Activities	66
	Construction Vehicle Movements	48
N7	Site Clearance	62
	Infill to Depth of 3m and site preparation	63
	General Site Activities	67
	Construction Vehicle Movements	49

* Construction vehicles on King Hamad Highway

The existing noise climate at receptors close to the construction works is represented by the baseline noise survey where the daytime noise levels range from $L_{Aeq,T}$ 57 to 68 dB. This indicates that the receptors in this area fall within Category A (see **Table 8.1**) with the exception of site N2, which falls within Category B. The Construction Noise limit is 65 dB $L_{Aeq,\ 12\ hr}$ in the daytime, 55 dB $L_{Aeq,\ 4\ hr}$ in the evening and 45 dB $L_{Aeq,\ 8\ hr}$ in the night-time at site N1 and sites N3 to N7 and 70 dB $L_{Aeq,\ 12\ hr}$ in the daytime, 60 dB $L_{Aeq,\ 4\ hr}$ in the evening and 50 dB $L_{Aeq,\ 8\ hr}$ in the night-time at site N2.

Based on the predicted noise levels in **Table 8.11**, the daytime noise limits will not be exceeded by site clearance, site preparation and vehicle movement noise. General site activities are predicted to exceed the daytime noise limit by up to 2 dB at sites N5, N6 and N7. Major construction works are not scheduled to take place in the evening/night periods.

The predicted construction noise levels are considered to provide a negligible to minor short term adverse effect in the daytime.

8.5.3 Construction Vibration

Damage to buildings associated solely with ground-borne vibration is not common and although vibration may be noticeable, there is little evidence to suggest that it may produce cosmetic damage such as a crack in plaster unless the magnitude of the vibration is excessively high. The most likely impact, where elevated levels of vibration do occur during the demolition and construction phases, is associated with perceptibility. There are currently no British Standards that provide a methodology to predict levels of vibration from construction activities, other than that contained within BS 5228-2:2009+A1:2014, which relates to percussive or vibratory piling only.

Table 8.12 below details the distances at which certain activities could give rise to a just perceptible level of vibration. These figures are based on historical field measurements.

Table 8.12 Distances at Which Vibration May Just be Perceptible

Construction Activities	Distance from Activity when Vibration may Just be Perceptible (m)
Excavation	10 – 15
Heavy Vehicles (e.g. dump trucks)	5 – 10
Hydraulic Breaker	15 – 20

Table 8.12 shows that the magnitude of any perceptible vibration depends strongly on the type of construction work. It also shows that that when receptor locations are more than 20m from construction activities, vibration is unlikely to be perceptible and will be well below levels whereby annoyance or structural damage is caused.

Based on the figures in **Table 8.12**, it is considered that at all receptor locations, vibration will be well below 0.15 mm/s PPV, which when compared with the criteria provided in the referenced guidance adopted in this assessment would be negligible. As such, it is considered that vibration associated with construction activities at the BMP will be adequately controlled and that no specific mitigation measures will be necessary.

8.5.4 Operational Phase

The predicted operational noise levels noise at Receptors N1 to N7 based on noise from the new process units are shown in **Table 8.13**, below.

Table 8.13 Operational BMP Noise Levels, L_{den} dB(A)

Receptor	Predicted Noise Level	Target Noise Level, $L_{Aeq,T}$ dB		
	L_{den} dB(A)	Day	Evening	Night
N1	34	60	55	50
N2	38	60	55	50
N3	40	60	55	50
N4	51	60	55	50
N5	54	60	55	50
N6	33	60	55	50
N7	61	60	55	50
Lden : Day-evening-night equivalent level: This is the A weighted Leq noise level, over a 24 hour period, with a 10 dB penalty added to the levels between 23.00 and 07.00 hours and a 5 dB penalty added to the levels between 19.00 and 23.00 hours to reflect people's extra sensitivity to noise during the night and the evening.				

The Bahrain Noise Guidelines values for residential areas with some commercial activity in the day, evening and night-time periods are shown in **Table 8.13**. Although the predicted noise levels from the BMP are provided as L_{den}, these provide a positive indication that the BMP noise levels are below the day and evening noise ($L_{Aeq,T}$) limits at all sites with the exception of Site N7. The noise predictions indicate that the night-time noise limit may be exceeded at sites N4 and N5 as the L_{den} values are within 1 to 4 dB of the Bahrain Noise Guidelines values at night. The night-time noise limit would also be exceeded at site N7. This indicates that noise from the BMP is within acceptable levels in the day and evening periods with the exception site N7, which is adjacent to the Bapco fence line near to lay down areas. The daytime noise effect from the operational BMP is considered to be negligible at sites N1 to N6. The evening and night-time noise is considered to provide a minor adverse effect.

The baseline noise survey indicates that the existing noise levels at site N7 are $L_{Aeq,T}$ 61.7 dB in the daytime, 54.1 dB in the evening and 54.5 dB at night. The predicted noise level from the BMP of L_{den} 61 dB(A) is below the existing daytime noise level at this location and would provide a noise increase of 3 dB, which is considered to provide a minor adverse effect. In the evening and night-time periods the BMP noise would provide a noise increase of 7 to 8 dB and this is considered to be a moderate adverse effect. However, site N7 is a BMP construction labour camp and will not be present during the operational phase of the BMP.

The noise effect of the BMP is considered to be negligible in the daytime and evening periods and a minor adverse effect at night at sites N1 to N6. The operational BMP noise will not affect site N7 as this is a construction labour camp and will not be present once construction is completed.

8.6 Mitigation

8.6.1 Construction Phase

Noise from site clearance, site preparation and vehicle movements is predicted to be within acceptable levels in the daytime period, when it is anticipated that the majority of construction works will take place. General site activities are predicted to exceed the daytime noise limit by up to 2 dB at sites N5, N6 and N7. The noise limit is exceeded in the evening and night-time periods and mitigation measures would be required at sites

N3, N4, N5, N6 and N7 if construction works take place in the evening or night-time periods. Assuming that construction activities will only take place in the day, then Best Practicable Means (BPM) are required to minimise construction noise from general site activities, when this takes place near to sites N5, N6 and N7. BPM would include such things as powering down equipment when not in use, use of “silent” generators, ensuring that noise baffling enclosures are fully closed when machinery is operating, ensuring that plant is well maintained etc.

Major construction activities are not scheduled to take place in the evening or night-time periods.

It is considered that at all receptor locations, construction vibration will be negligible and no specific mitigation measures will be necessary.

8.6.2 Operational Phase

The predicted BMP noise levels provide a positive indication that the noise levels are below the day and evening noise limits at all sites with the exception of Site N7, which is a BMP construction labour camp. The night-time noise limit would also be exceeded at site N7. As stated previously, the operational BMP noise will not affect site N7 as this is a construction labour camp and will not be present once construction is completed.

The noise predictions also indicate that the night-time noise limit may be exceeded at sites N4 and N5 as the L_{den} values are within 1 to 4 dB of the Bahrain Noise Guidelines values at night. It is likely that during the EPC Phase of the project more details will be available from equipment manufacturers regarding the BMP noise emissions, and careful design may be able to further reduce noise emissions. If not, then appropriate noise mitigation measures such as acoustic barriers or enhanced sound insulation measures should be considered at the accommodation blocks at N4 and N5 to reduce the operational noise effects of night-time noise from the BMP.

8.7 Summary

Table 8.14 below provides a summary of noise and vibration impacts and proposed mitigation measures. The operational noise assessment will be revised during EPC Phase to consider noise emission data provided by the equipment manufacturers or mitigation will be provided to reduce the noise impact on N4 and N5.

8.8 References

(BSI, 1993) BS 7385:1993 ‘Evaluation and Measurement for Vibration in Buildings’ Part 2: Guide to Damage Levels from Ground-Borne Vibration.

(BSI, 2008) BS6472-1:2008 Guide to Evaluation of Human Exposure to Vibration in Buildings, Part 1: Vibration Sources other than Blasting.
BSI, 2014 - BS8233:2014 Sound Insulation and Noise Reduction for Buildings.

(BSI 2014A) BS 5228-1:2009+A1:2014 Code of Practice for Noise and Vibration Control on Construction and Open Sites.

(BSI, 2014B) BS 5228-2:2009+A1:2014 Code of Practice for Noise and Vibration Control on Construction and Open Sites. Vibration

(DoT, 1988) Calculation of Road Traffic Noise, UK Department of Transport, 1988

(Highways Agency, 2011) Design Manual for Roads and Bridges (DMRB) Volume 11, Section 3 Part 7 – HD 213/11 Noise and Vibration, 2011

(NPL Report CMAM 16, 1998) Health Effect-Based Noise Assessment Methods: A Review and Feasibility Study, 1998

(UK Gov, 1975) The Noise Insulation Regulations, 1975

(UK Gov, 1988) The Noise Insulation (Amendment) Regulations, 1988

(World Bank, 2007) World Bank EHS Guidelines, General EHS Guidelines, World Bank Group, 2007

(WHO, 1999) World Health Organisation (WHO) document ‘Guidelines for Community Noise’, 1999

Table 8.14 Summary of Noise and Vibration Impacts

Impact	Significance	Mitigation/Enhancement Measures	Residual Impact
Construction Phase			
Day	Negligible to Minor Adverse	Best Practicable Means regarding construction methodology and equipment. Major construction works will not take place in evening/night periods.	Negligible to Minor Adverse
Evening	Minor Adverse	Major construction works will not take place.	Negligible
Night	Major Adverse	Major construction works will not take place	Negligible
Construction Vibration	Negligible	None	Negligible
Operational Phase			
Operational Plant/Machinery Noise	Negligible to Minor Adverse	In case results of EPC noise study confirm a minor adverse effect on N4 and N5, mitigating measures shall be applied	Negligible to Minor Adverse

9 HYDRODYNAMICS AND WATER QUALITY

9.1 Introduction

The release of industrial effluents has the potential to impact marine water quality, marine sediment quality and marine ecology. This section considers the potential impact of the BMP on water quality. The impacts on marine sediment and marine ecology are considered in **Sections 10** and **11** respectively.

As is detailed in this ESIA, the BMP is not expected to significantly change the volume or composition of the effluents from the Refinery. Hence, in this respect, the impact of the BMP on marine water quality during operation is expected to be small. As such, the purpose of this section is to benchmark the impact of the Refinery outfalls on water quality in Farisiyah Bay (AOI 1).

In addition to the Refinery outfalls there are a number of other possible impacts on water quality arising from BMP construction works and these are assessed in detail.

This section is based on the findings of the Marine Environmental Baseline Survey (MEBS) Report which is included as **Appendix 9A** and a hydrodynamic modelling study of the Refinery outfalls undertaken by HR Wallingford Ltd., which is included as **Appendix 9B**.

9.2 Legislation and Guidance

We have identified water quality standards/objectives, which are pertinent to the development; these are derived from a variety of sources including national, regional, and international. The full list of standards has been included in **Appendix 9C**.

<u>Standards for Water Quality Objectives (WQOs)</u>

- The KSA Environmental Quality Objectives (EQOs) for Ambient Marine Water Quality, Presidency of Meteorology and Environment (PME), 2012. The KSA guidelines (Arabian Gulf) may be considered relevant to Bahrain based on the similarity of their marine environments; these two countries are very similar biogeographically. These ambient water quality standards are for 3 classifications of marine waters; Coastal Marine, Coastal High Value and Coastal Industrial[16].
- United States Environmental Protection Agency (USEPA) National Recommended Water Quality Criteria (USEPA, 2014). The US EPA have 2 guideline values, the Criteria Maximum Concentration (CMC), and the Criterion Continuous Concentration (CCC). The CMC ('acute' scenario) is an estimate of the highest concentration of a material in surface water, which an aquatic community can be briefly exposed to without resulting in an unacceptable effect. The CCC ('chronic' scenario) is an estimate of the highest concentration of a material in surface water which an aquatic community can be exposed indefinitely to without resulting in an unacceptable effect.
- Canadian Council of the Ministers of the Environment – Canadian Water Quality Guidelines for the Protection of Aquatic Life (CCME, 2014).

[16] For the purpose of the ESIA only Coastal Marine and Coastal High Value guidelines are considered.

- UK Environment Agency – Environmental Quality Standards (EQS) − based upon substances detailed in the European Union's Dangerous Substances Directive (76/464/EEC and Daughter Directives). The EQS have been developed for the protection of aquatic life.
- Dubai Municipality - Marine Water Quality Objectives (Dubai Municipality, 2003).
- Australian Government - Department of Environment and Resource Management – Queensland Water Quality Guidelines (DERM, 2009). These technical guidelines have been developed primarily for the protection of Queensland aquatic ecosystems; however, they provide a useful benchmark for the current study.

Standards for Effluents Discharged to Sea/Sewer

- SCE (2010) EIA-8 Guidelines on Key Environmental Mitigation Measures Pertaining to Reclamation Methodologies of Large-Scale Projects.
- SCE (2010) EIA-9 Guidelines on TSS monitoring Programme of Large Scale Projects Involving Intensive Dredging and Reclamation Operations.
- Kingdom of Bahrain Ministerial Order No. 3 of 2001 – Amendments to Tables in Ministerial Order No. 10 of 1999 with Respect to Environmental Standards (Air and Water) and its Amendments in Ministerial Order No. 2 of 2001.
- World Bank (2007) General EHS Guidelines.
- Ministry of Works (MoW) "TSE standards for agriculture unrestricted reuse and discharge to sea – sensitive areas".
- Ministry of Works Sanitary Engineering Affairs - Trade Effluent Conditions of Discharge.

Reference to specific values for all stated guidance is clearly stated throughout this section, where applicable, and/or with the standalone Marine Environmental Baseline Survey Report (MEBS, **Appendix 9A**).

9.3 Assessment Methodology

A quantitative water quality impact assessment was undertaken via a review of secondary and primary water quality data sets, and via numerical hydrodynamic dispersion modelling studies.

9.3.1 Secondary Data

Key data sets were provided by Bapco and comprised:

- Bapco (2011) Marine Environment Assessment[17]. This reports presents, amongst others, long-term marine water quality data in areas affected by Bapco effluents, and is the seventh report over a period of 30 years of assessment. The geographical extent of this study encompasses AOI 1, and adjacent areas to the north, east and south of the existing Refinery. **Section 9.4** provides a summary of pertinent data.

[17] Olof Lindén, PhD. and Ulf Larsson, PhD.

- Bapco (2014-2015) Refinery Effluent Quality Data. Provides effluent characteristics for the main cooling outfall and #6 OWS for the years 2014-2015 (**Table 9.6** and **Table 9.7**). **Section 9.4** discusses these data sets.

9.3.2 Primary Data

EACS was commissioned to undertake primary water quality assessment of receiving waters in order to assess any underlying levels of contamination, which may be originating from existing operational Bapco discharges. The findings of the study are presented in the stand alone Marine Environmental Baseline Report (EACS, 2016 Marine Environmental Baseline Survey), and summarised in **Section 9.4**.

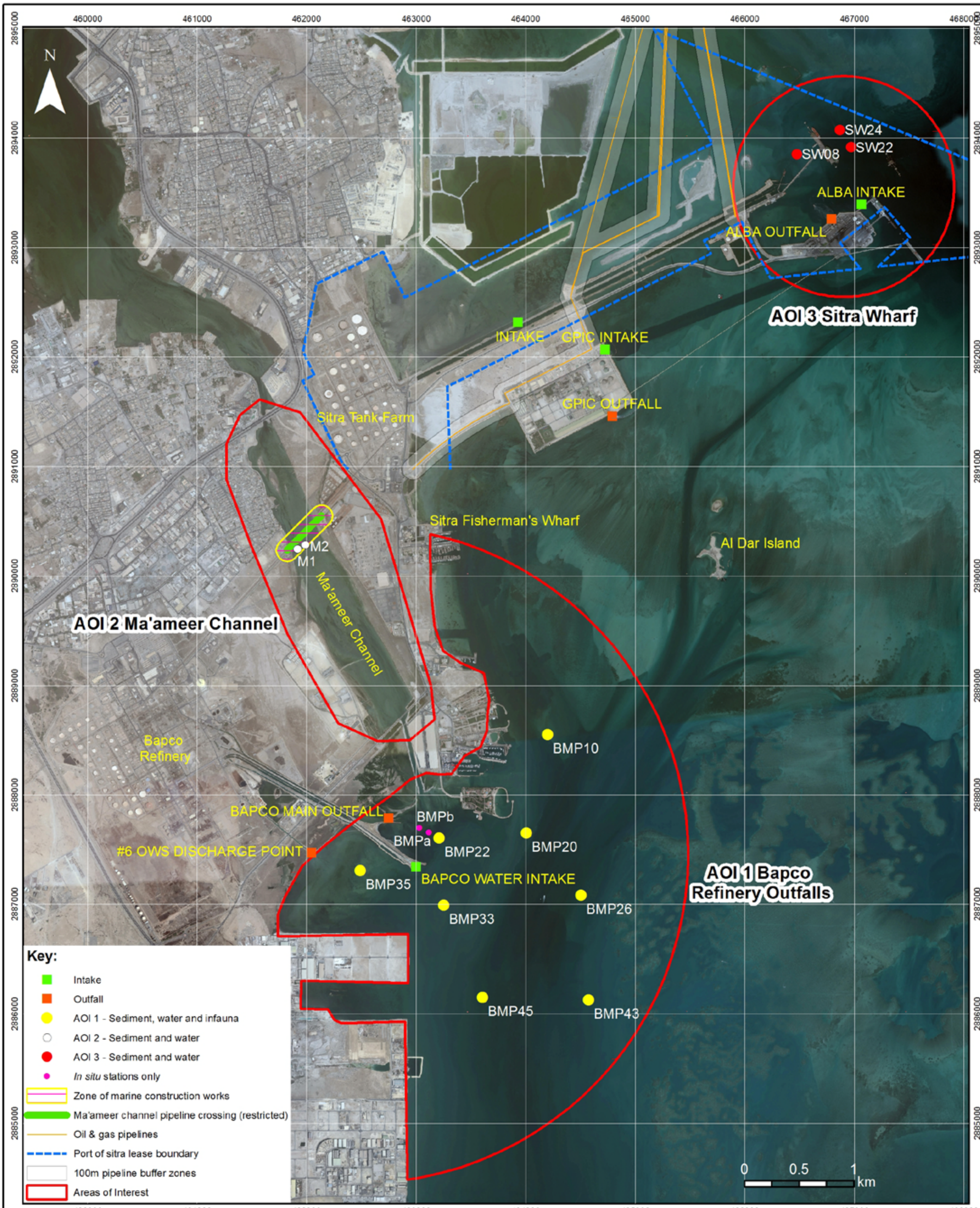
9.3.2.1 Water Quality Survey Methodology

Thirteen water samples were taken; eight from AOI 1, two from AOI 2 (by hand due to shallow water depth), and three from AOI 3 (**Figure 9.1**). Water samples were collected using a 2L Niskin sampler at mid-water column depth[18] and tested according to strict protocols by ALS Arabia laboratories, in Saudi Arabia, for the parameters indicated in **Table 9.8**.

In situ[19] water measurements were also recorded at each location using a HACH MS5 multi-probe at three depths, 1 m from the surface, mid-water column, and 1 m from the seabed. At locations less than 4 m depth, only a mid-water column reading was recorded. The reader is directed to the MEBS Report for full details (**Appendix 9A**).

[18] With the exception of the 'TPH' parameter (sample collected from surface waters and up-current of the survey vessel to avoid contamination from engine discharges).

[19] Temperature (ºC), Salinity (ppt), Sp. conductivity (mS/cm), Dissolved oxygen (mg/l), pH and Turbidity (NTU).



Title: Location of Infauna, Sediment Sampling and Water sampling Locations (AOI 1, 2 & 3)		Client: Bapco Technip
Project: Bapco Modernization Program		
Date: February 2016	Figure No.: 9.1	Consultant: Environment Arabia
Datum: WGS 84 - UTM 39N	Scale: 1:45,000 (A4)	

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9.3.3 Hydrodynamic Modelling

Dispersion modelling studies were carried out to quantitatively assess the geographical extent of thermal plumes arising from the discharge of effluent from the two Bapco outfalls (i.e. main outfall and OWS#6). As the pre- and post-BMP discharge regimes have been determined to be very similar, only a single discharge scenario was run (**Section 9.3.3.1**); care was taken to ensure that any coastal configurations, which may affect the dispersion effluents, were taken into account particularly that associated with the 2030 layout for the Bahrain National Planning Development Strategy (NPDS), supplied by General Directorate for Urban Planning.

Modelling was deemed necessary in order to develop appropriate future monitoring programmes and to assess potential impacts upon sensitive receptors.

HR Wallingford have prepared a standalone modelling report full report, which is appended to this document (**Appendix 9B**), although a summary of the methodology and findings are presented in **Section 9.5**.

9.3.3.1 Methodology for Hydrodynamic Modelling

Dispersion of the Bapco discharges was examined using the TELEMAC finite element modelling system. TELEMAC represents the area of interest using a completely flexible mesh of triangular elements.

TELEMAC-3D, the three dimensional module of the TELEMAC system, was used to allow the simulation of the vertical transport and structure of the effluent plumes. This solves the equations of motion and transport in multiple layers, including the important effects of buoyant spreading, inhibition of vertical mixing associated with sharp density gradients, and shear of wind-driven currents. Important atmospheric processes, including cooling of surface plumes to the atmosphere, are also represented.

Model sensitivity tests during HR Wallingford's previous study[20] indicated that the flow from the Ma'ameer Channel does not have a significant effect on thermal dispersion at the Bapco site, therefore was not included in the simulations.

Key conditions were set within the model, key being coastal configuration and discharge flow rates. The BMP project will not affect the layout of existing intake and outfall facilities[21], and is not expected to produce any significant changes to the existing flow rates, discharge excess temperatures and water quality (**Section 2**). Modelling was carried out for the maximum, minimum and average discharge volumes from both the main outfall and OWS#6.

Tides were selected to simulate a typical spring-neap cycle, specifically for the period 21st November to 9th December 2015, for which the model was recently re-calibrated. Winds were represented in the model using data from Bahrain International Airport to

[20] HR Wallingford previously assessed intake water quality for the existing Bapco Refinery in 2008: Bapco Intake Water Quality Assessment - Data review and calibration, HR Wallingford Report EX 5679, 2008, and Bapco Intake Water Quality Assessment - Thermal dispersion and sediment transport, HR Wallingford Report EX 5698, 2008.

[21] The Refinery operates a single cooling water intake, which abstracts seawater from Farisiyah Bay through a low-lift pump house (LLPH) situated approximately 700 m offshore and at the distal end of an intake channel between two breakwaters (**Figure 2.4** and **Figure 9.1**).

select representative and adverse wind conditions. Generally winds are from north-west, at typical speeds around 5 m/s. Weaker winds blow from east and southeast around 5% of the time.

The modelling was undertaken for the following conditions:

- Winter, summer and average ambient and discharge conditions;
- Typical and weak wind conditions.

The dispersion of effluents was assessed in terms of the excess temperatures as compared to baseline (ΔT°C). All simulations were run for 18 days allowing for a spin-up time[22] of 3 days, followed by a complete spring-neap tidal cycle over 15 days.

Ambient temperature conditions were derived from HR Wallingford's experience of working in Bahrain, informed by historic data and long-term monitoring. Discharge flow rates and temperatures were provided by Bapco and are highlighted in **Tables 9.1** – **9.3**.

Table 9.1 Summer Conditions

	Main Outfall	OWS#6	Intake
Flow rate (m^3/day)	1,004,074	163,775	1,167,849
Flow rate (m^3/s)	11.6	1.9	13.5
Ambient temperature (°C)	35.0	35.0	35.0
Discharge excess temperature (°C)	13.0	10.5	-

Table 9.2 Winter Conditions

	Main Outfall	OWS#6	Intake
Flow rate (m^3/day)	752,232	131,020	883,252
Flow rate (m^3/s)	8.7	1.5	10.2
Ambient temperature (°C)	19.0	19.0	19.0
Discharge excess temperature (°C)	10.5	10.5	-

Table 9.3 Average Conditions

	Main Outfall	OWS#6	Intake
Rate (m^3/day)	752,232	131,020	883,252
Flow rate (m3/s)	8.7	1.5	10.2
Ambient temperature (°C)	25.0	25.0	25.0
Discharge excess temperature (°C)	11.0	8.5	-

Dispersion simulations were repeated for the average discharge, using the proposed 2030 NPDS layout. In this simulation, future proposed reclamation encompasses the existing OWS#6 outfall; hence, the outfall has been extended along its present alignment so that it would discharge to the sea from the periphery of the reclamation.

[22] "Spin-up" is a period at the start of the simulation that allows the model to settle down, and eliminate any start-up transients, etc. In this particular case, the main effect is to allow a build-up of heat in the background, so that a quasi-steady state can be analysed.

The model simulations also included a conservative (that is, non decaying) tracer discharged at unit concentration from the main and OWS#6 outfalls. The results presented are the average footprints derived from the model results.

These concentration fields have been used to estimate the diluted concentrations of dissolved chemicals that are likely present in the effluents (**Section 9.5.4**) by use of a conservative tracer.

9.3.4 Assessment Criteria and Methodology

Assessment of water quality addresses both the quality of existing, and future state of marine waters (i.e. following discharge and dispersion of effluents to a known concentration). As the quality of marine waters is key in sustaining a healthy marine environment and the operational efficiency of industrial facilities, a high sensitivity criteria is assigned.

Our methodology of quantifying impacts is based on the product of the sensitivity of the receptor (all bodies of water have been classified as high sensitivity) and the magnitude of the impact. Using a combination of these factors, a consistent set of impact significance levels has been applied (**Table 9.4**).

Quantifying the magnitude of an impact is defined via a number of sub-criteria. Typically, these may be informed following specialist modelling studies, expert opinion, review of contractor's methodologies, and reference to published data (e.g. water quality guidelines). Criteria include:

- **Extent:** whether the impact would occur onsite, in a limited (Li) area (within 1 km of the site); local (Lo) area (within, say, 5 km of the site or within the relevant Municipality); nationally (na) or internationally (in).
- **Duration:** whether the impact would be temporary (T-less than one year), short-term (ST-one to five years), medium term (MT-five to ten 10 years), long-term (LT-over ten years), or permanent (P).
- **Likelihood:** based on the best available information (primary and secondary data), the likelihood of an impact is assigned a classification based upon the probability of an event occurring (i.e. unlikely (U), likely (Li), and definite (De)).
- **Magnitude:** the quantifiable effects of impacts, measured where appropriate against an appropriate environmental standard (national, regional or international) or based on expert judgment.
- **Direct** (D): impacts that result from direct interaction between a project activity and the receiving environment (e.g. direct source of pollution into a water body).
- **Indirect** (I): impacts that result from other activities as a consequence of the project (e.g. reduction in water quality affects fish and therefore impairs fisheries activities).

These criteria are incorporated within the impact summary tables (**Table 9.21** and **Table 9.22**).

To calculate the level of significance, the formula presented below has been utilised.

Impact significance = magnitude of impact X sensitivity of receptor

The formula provides a better appreciation of the fact that as the sensitivity of the environment and the magnitude of the effect increases, so the significance of that effect increases (**Table 9.4**).

Table 9.4 Calculation of Impact Significance

MAGNITUDE	**High**	Minor/Moderate	Moderate	Moderate/Major	Major
	Medium	Minor	Minor/Moderate	Moderate	Moderate/Major
	Low	Negligible/Minor	Minor	Minor/Moderate	Moderate
	Negligible	Negligible	Negligible	Negligible/Minor	Minor/Moderate
		Negligible	**Low**	**Medium**	**High**
		VALUE AND SENSITIVITY			

Table 9.5 Significance of impact

Impact significance	Impact characteristic
Negligible	Impact is virtually imperceptible over baseline
Minor Adverse	Impacts are of low intensity with short-term duration. The potential for recovery to existing conditions is good with return to baseline conditions over a short period of time
Moderate Adverse	Activities are likely to result in significant physical/chemical/biological impacts in the medium term and from which the potential for partial recovery exists.
Major Adverse	Activities will result in significant change to existing physical, chemical or biological conditions of marine sediments. This may arise due to construction works (e.g. dredging), changes in natural sediment transport regimes, or contamination via anthropogenic activities. The potential for a return to baseline conditions is extremely low; impacts are considered long term and/or permanent.

9.4 Baseline

9.4.1 Secondary Data - Bapco (2011) Marine Environment Assessment

Bapco (2011) assessed water quality for specific parameters including temperature and salinity, nutrients, chlorophyll concentrations and phytoplankton). Metals were only introduced as part of the 2011 campaign and hence only a single data set exists; key observations are presented below. Previous campaigns addressed nutrients (ammonium, DIP phosphate, nitrate and nitrite), temperature and salinity, phytoplankton and primary production. Key results from the 2011 survey are presented in the following bullet points:

- Aluminium ranged from 51.5 mg/l to 8.28 mg/l. When comparing the results of EACS 2016 to those recorded during the Bapco 2011 survey, they are significantly lower (by a factor of over 10 fold) - 8.28 mg/l to 23.9 mg/l. In the Bapco study, the water samples were collected in a gradient from the mouth of the main outfall to a distance about 300 m outside of the pump house (close to EACS station BMP 22).

- Molybdenum ranged from 23.1 mg/l to 10.8 mg/l during the Bapco 2011 survey. In comparison, molybdenum was 'not detected' in any of the water samples collected from AOI 1 (all <0.001 mg/l) during the EACS 2016 survey. The results obtained during the Bapco 2011 marine assessment were, therefore, over 10,000 times the EACS recorded values.
- Vanadium ranged from 2.27 mg/l to 3.54 mg/l during the Bapco 2011 survey. In comparison vanadium was 'not detected' in any of the water samples collected from AOI 1 (all <0.01 mg/l) during the EACS 2016 survey. The results obtained during the Bapco 2011 marine assessment were, therefore, over 1,000 times the EACS recorded values.

Bapco (2011) reported that contrary to previous survey campaigns, no elevation of ammonium concentrations near the Bapco discharge were observed during the 2011 survey. Furthermore, Bapco (2011) states that '*there was no clear relation between the yearly average nutrient concentrations in the Refinery effluent and nutrient concentrations in receiving waters near the outfall*.'

9.4.2 Outfall Effluent Characteristics

The effluent characteristics arising from the main Bapco, and OWS#6 outfalls, for the years 2014 and 2015 are presented in **Table 9.6** and **Table 9.7** respectively. These have been compared to the BSIE[23] to indicate any breaches; review of the main outfall data indicates that over the 2-year data set, the maximum values for all parameters were not exceeded.

Data associated with OWS#6 indicates that the allowable maximum value for phosphorus (total - 2.0 mg/l)), was exceeded on a single occasion (5/05/2015, 4.09 mg/l was recorded). Furthermore, during this same period, the maximum allowable value for hydrocarbons (0.1 mg/l) was exceeded on the 03/02/15 with a recorded value of 0.30 mg/l

This information is presented as it represents the predicted typical effluent characteristics associated with post BMP; no specific data has been provided other than post BMP will be in line with BSIE.

[23] Note the results in **Table 9.4** and **9.5** have only be compared with the maximum values as a single result is not representative of the monthly average.

Table 9.6 Effluent Characteristics for the Bapco Main Cooling Water Outfall 2014 and 2015 in Relation to the Bahrain Industrial Effluent Standards

Parameter	Units	Limit of Detection	Bahrain Standards for Industrial Effluents		Measured Values							
			Monthly Average	Maximum	04/02/2014	06/05/2014	05/08/2014	04/11/2014	03/02/2015	05/05/2015	04/08/2015	03/11/2015
Physico-chemical pollutants												
Floating particles	mg/l	-	0	0	0	0	0	0	0	0	0	0
pH	-	-	6 to 9	9	8.2	7.7	7.9	8	7.8	7.8	8.2	7.8
Temperature[24]	°C	-	3°C Δ T	-	30.0	44.2	45.3	39	32.5	41.3	45.0	47.0
Total Suspended Solids	mg/l	2	20	35	6.2	9.2	10.8	21	22.0	5.2	9.6	8.2
Turbidity	NTU	0.1	25	75	1.0	5.2	1.4	1	1.0	0.3	3.5	1.4
Inorganic Pollutants												
Ammoniacal Nitrogen as N	mg/l	0.1	1	3	0.1	0.1	<0.1	0.1	<0.1	0.8	0.8	0.4
Dissolved Oxygen	mg/l	-	-	-	7.9	7.8	8.7	6.0	8.3	8.2	8.7	9.0
Sulphide as H_2S	mg/l	0.1	0.5	1	0.1	0.1	0.6	<0.1	<0.1	<0.1	0.3	0.3
Chlorine residual	mg/l	0.2	0.5	2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Cyanide	mg/l	0.002	0.05	0.1	<0.002	0.003	<0.002	<0.002	<0.002	0.002	0.002	0.002
Chloride	mg/l	-	-	-	39000	40000	42500	41500	41000	41000	41000	41500
Nitrate (NO_3)	mg/l	0.01	-	10	0.80	1.00	1.80	1.14	2.20	0.39	0.8	1.6
Nitrite (NO_2)	mg/l	0.001	-	1	0.004	0.043	0.005	0.005	0.005	0.002	0.005	0.002
Phosphorous total	mg/l	0.01	1	2	0.20	0.35	0.18	0.96	0.19	1.00	0.40	0.47
Methylene blue active substances	mg/l	0.03	0.5	1	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
Flouride	mg/l	0.2	15	25	1.6	1.4	1.8	2.2	2.0	1.7	2.0	3.3
Organic Pollutants												
Biological Oxygen Demand (BOD)	mg/l	5	25	50	<5	<5	<5	<5	<5	8	6	6
Chemical Oxygen Demand (COD)	mg/l	5	150	350	135	50	117	50	50	50	14	50
Total Kjeldahl Nitrogen	mg/l	1	5	10	<1	<1	<1	3	3	<1	0.7	0.4
Hydrocarbons	mg/l	0.01	0.1	0.1	0.05	0.05	0.05	0.05	0.05	<0.01	0.05	0.05
Oil and grease	mg/l	0.2	8	15	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	0.30
Phenols	mg/l	0.1	0.5	1	0.1	0.1	0.1	<0.1	0.1	0.3	0.2	0.1
Total coliforms	No./100ml	-	1000	10000	0	0	0	0	0	0	0	0
Total Organic Carbon (TOC)	mg/l	1	50	-	1.0	4.4	2.6	3.9	3.8	3.9	2.2	2.3
Trace Metals												
Aluminium	mg/l	1	15	25	1	1	1	1	<1	<1	<1	<1
Arsenic	mg/l	0.002	0.1	0.5	0.002	0.002	0.002	0.002	<0.002	0.002	0.002	0.002
Cadmium	mg/l	0.1	0.01	0.05	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	0.1	0.1
Chromium total	mg/l	0.1	0.1	1	0.1	0.1	0.1	0.1	<0.1	0.1	0.1	0.1
Copper	mg/l	0.1	0.2	0.5	0.1	0.1	0.1	0.1	<0.1	0.1	0.1	0.1
Iron	mg/l	0.1	5	10	0.1	0.1	0.1	0.1	<0.1	0.1	0.1	0.1
Lead	mg/l	0.1	0.2	1	0.1	0.1	0.1	0.1	<0.1	0.1	0.1	0.1
Mercury	mg/l	0.002	0.001	0.005	0.002	0.002	0.002	0.002	<0.002	0.002	0.002	0.002
Nickel	mg/l	0.1	0.2	0.5	0.1	0.1	0.1	0.1	<0.1	0.1	0.1	0.1
Zinc	mg/l	0.1	2	5	0.1	0.1	0.1	0.1	<0.1	0.1	0.1	0.1

Key: - No standard. NTU - Nephelometric Turbidity Units. Red shading and bold test = exceedance of maximum value

[24] Values presented are do not represent ΔT, they represent actual values recorded at the outfall.

Table 9.7 Effluent Characteristics for #6 OWS Outfall 2014 to 2015 in Relation to the Bahrain Industrial Effluent Standards

Parameter	Units	Limit of Detection	Bahrain Standards for Industrial Effluents		Measured Values							
			Monthly Average	Maximum	04/02/2014	06/05/2014	05/08/2014	06/11/2014	03/02/2015	05/05/2015	04/08/2015	03/11/2015
Physico-chemical pollutants												
Floating particles	mg/l	-	0	0	0	0	0	0	0	0	0.0	0.0
pH	-	-	6 to 9	9	8.1	7.7	7.8	7.4	7.6	7.9	8.2	8.1
Temperature[25]	°C	-	3°C ∆ T	-	22.0	33.5	45.3	29.0	33.0	42.0	47	46
Total Suspended Solids	mg/l	2	20	35	5	5	10	24	21	1	8.4	13.0
Turbidity	NTU	0.1	25	75	1.0	0.2	1.5	1.0	1.0	0.2	3.2	2.2
Inorganic Pollutants												
Ammoniacal Nitrogen as N	mg/l	0.1	1	3	0.1	0.1	0.2	0.1	<0.1	1.6	0.6	0.4
Dissolved Oxygen	mg/l	-	-	-	6.9	7.5	8.6	5.9	8.3	8.2	7.6	8.3
Sulphide as H_2S	mg/l	0.1	0.5	1.0	0.1	0.1	0.3	0.1	<0.1	<0.1	0.5	0.2
Chlorine residual	mg/l	0.2	0.5	2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	0.02	0.05
Cyanide	mg/l	0.002	0.05	0.1	0.002	0.004	0.002	0.002	0.002	0.002	0.002	0.002
Chloride	mg/l	-	-	-	40000	40000	41500	41000	42500	40500	41000	41500
Nitrate (NO_3)	mg/l	0.01	-	10	0.80	0.90	2.20	0.92	1.80	0.47	1.200	1.500
Nitrite (NO_2)	mg/l	0.001	-	1	0.005	0.007	0.005	0.009	0.009	0.002	0.006	0.002
Phosphorous total	mg/l	0.01	1	2	0.3	0.20	0.17	0.10	0.28	**4.09**	0.40	0.39
Methylene blue active substances	mg/l	0.03	0.5	1	0.01	0.01	0.01	<0.03	<0.03	<0.03	<0.03	<0.03
Fluoride	mg/l	0.2	15	25	1.7	1.4	1.8	2.0	2.1	1.8	2.4	3.5
Organic Pollutants												
Biological Oxygen Demand (BOD)	mg/l	5	25	50	<5	<5	<5	<5	<5	<5	2	3
Chemical Oxygen Demand (COD)	mg/l	5	150	350	135	50	113	50	50	50	52.0	50.0
Total Kjeldahl Nitrogen	mg/l	1	5	10	<1	<1	<1	2.8	2.3	<1	<1	<1
Hydrocarbons	mg/l	0.01	0.1	0.1	0.05	0.05	0.05	0.05	**0.30**	0.05	0.10	0.05
Oil and grease	mg/l	0.2	8	15	<0.2	<0.2	<0.2	<0.2	1.30	<0.2	<0.02	<0.2
Phenols	mg/l	0.1	0.5	1	0.1	0.1	0.1	0.1	<0.1	0.2	0.2	0.1
Total coliforms	No./100ml	-	1000	10000	0	0	0	0	0	0	0	0
Total Organic Carbon (TOC)	mg/l	1	50	-	1.0	4.2	2.2	4.1	4.5	2.5	2.4	2.8
Trace Metals												
Aluminium	mg/l	1	15	25	1	1	1	1	<1	<1	<1	<1
Arsenic	mg/l	0.002	0.1	0.5	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
Cadmium	mg/l	0.1	0.01	0.05	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Chromium total	mg/l	0.1	0.1	1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Copper	mg/l	0.1	0.2	0.5	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Iron	mg/l	0.1	5	10	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Lead	mg/l	0.1	0.2	1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Mercury	mg/l	0.002	0.001	0.005	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
Nickel	mg/l	0.1	0.2	0.5	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Zinc	mg/l	0.1	2	5	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1

Key: - No standard. NTU - Nephelometric Turbidity Units. Red shading and bold test = exceedance of maximum value

[25] Values presented are do not represent ΔT, they represent actual values recorded at the outfall.

9.4.3 Primary Data - EACS (2016)

The following provides a brief summary of the parameters that were tested and analysed as part of the primary baseline surveys. The survey took place in January and February 2016 (winter).

- Metals - are conservative pollutants that are inert in the marine environment. They are not subject to bacterial degradation and so are essentially permanent additions to the marine environment.
- PAHs - are non-polar, lipophylic and persistent compounds in the marine environment and as such are of particular toxicological and environmental concern. PAHs are generally considered toxic to marine organisms due to their mutagenic and carcinogenic effects.
- 'Total Petroleum Hydrocarbons' (TPHs) - refers to any mixture containing one or more of several hundred chemical compounds found in crude oil. Petroleum hydrocarbons, are highly toxic to marine organisms at very low concentrations. In addition to direct lethal effects, petroleum hydrocarbons can exert sub-lethal effects, including reduced growth, altered feeding behaviour, and lower reproductive success (GESAMP 1993).
- Organotin compounds - are chemical compounds based on tin with hydrocarbon substituents and are typically classified according to their oxidation states. They are toxic endocrine-disruptor chemicals which bioaccumulate and even at very low levels they severely impact the health and development of marine organisms.
- Nutrients- such as nitrate are essential plant and algal nutrients and high levels in coastal waters may stimulate the growth of large quantities of marine plants and algae. When the plants and algae die, they are decomposed by aerobic bacteria, which utilise dissolved oxygen. This process is called 'eutrophication' and may result in a decrease in dissolved oxygen levels, leading to the death of aerobic organisms including fish and shellfish.

Table 9.8 provides a summary of the water quality results from each of the AOI. The results are discussed separately and in brief in the following sections.

9.4.3.2 Summary of Marine Water Quality within AOI 1

Within AOI 1 the water quality results were, for most parameters tested for, considered uncontaminated when considering the guidelines highlighted in **Section 9.2** and presented in **Appendix 9C** (ambient WQO). The following provides a summary of the few minor breaches in guideline values:

- Aluminium values were consistent across the study area, with a minimum of 0.6 mg/l recorded at stations BMP 33, 43 and 45, and a maximum value of 0.63 mg/l recorded at BMP 26; these breach the Dubai Marine WQO (0.2 mg/l) and the KSA EQO ambient water (C1 and C2 class waters) quality guideline (0.2 mg/l). When comparing the results to those recorded in Bapco (2011), EACS values are significantly lower (by a factor of > 10 fold).
- The KSA EQO for (total) phosphorus is 0.25 mg/l (C2) and 1.0 mg/l (C3 class waters). The values recorded in the study area ranged from 0.13 mg/l (BMP 33) to 0.47 mg/l (BMP 20). Half of the stations surveyed were within the guideline value

set for C2 classed (coastal) waters by KSA Presidency of Meteorology and Environment Protection (PME).

In situ water quality parameters were all within anticipated ranges for this location of Bahrain and time of year (i.e. January and February); with the exception of temperature readings at stations BMP 22a, 22b and 22c (see **Figure 9.1**). The temperature differential between locations a, b and c was 9.96 ºC with 19.42 ºC recorded at BMP 22a and 29.38 ºC recorded at BMP 22c.

At the remainder of the stations, the temperature ranged from 18.23 ºC (~ 1 m from the seabed at BMP 43)) to a maximum of 20.82 ºC (~ 1m from the surface at BMP 33) with an average of 19.27 ºC across all stations and depths.

9.4.3.3 Summary of Marine Water Quality within AOI 2

For most parameters tested for AOI 2, the results showed that the water is uncontaminated when considering the guidelines highlighted in **Section 9.2**. *In situ* water quality parameters were not recorded at AOI 2 due to shallow water depths. The following bullet points highlight the few minor breaches in guideline values:

- The value recorded for copper was 0.062 mg/l and 0.059 mg/ for station M1 and M2 respectively. These values are in breach of the KSA PME ambient water quality standards for C1 and C2 waters (coastal and high value), the UK EQS, and Dubai WQO. It is however compliant with the KSA PME ambient water quality standard (industrial waters) and both the US EPA CMC and CCC value for this parameter (see **Appendix 9C**).
- 0.054 mg/l zinc was recorded from the water sample M1 and 0.05 mg/l at M2. These values are above the UK EQS (set at 0.04 mg/l) and the Dubai WQO (0.02 mg/l). The values recorded are however compliant with all of the KSA EQS (for all classifications of water bodies), the US EPA CMC and CCC and US EPA CMC and CC values for this parameter (see **Appendix 9C**).
- Reactive phosphorus was recorded as 0.01 mg/l for both stations (M1 and M2) in AOI 2. This exceeds the Australian DERM (0.006 mg/l) but is compliant with the Dubai WQO (0.05 mg/l).

9.4.3.4 Summary of Marine Water Quality within AOI 3

Water quality recorded from the 3 locations in AOI 3 (**Table 9.8**) can be considered largely uncontaminated at the time of sampling when comparing the results to the guideline values highlighted in **Section 9.2** (i.e. no breaches recorded). Furthermore, in *situ* water quality results were all within ranges considered to be 'normal' for the geographical area and time of year.

Table 9.8 Summary of Water Quality Results (AOI 1, 2 & 3)[26]

Parameter		LOR	Unit	Station and AOI												
				AOI 1								AOI 2		AOI 3		
				BMP 10	BMP 20	BMP 22	BMP 26	BMP 33	BMP 35	BMP 43	BMP 45	M1	M2	SW 08	SW 22	SW 24
Inorganic Non-metals	Ammonium as N	0.01	mg/l	0.05	0.05	0.06	0.06	0.04	0.05	0.06	0.03	0.08	<5.0	0.52	0.08	0.07
	Silica	0.1	mg/l	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<1.0	<0.1	<0.1	<0.1
Metals - Total	Aluminium	0.01	mg/l	0.61	0.61	0.63	0.63	0.60	0.61	0.60	0.60	<0.01	11.0	<0.01	<0.01	<0.01
	Barium	0.001	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.148	<2.0	<0.001	<0.001	<0.001
	Cadmium	0.0001	mg/l	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	30.0	<0.0001	<0.0001	<0.0001
	Chromium	0.001	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	5.0	<0.001	<0.001	<0.001
	Cobalt	0.001	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.1	<0.001	<0.001	<0.001
	Copper	0.001	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.062	12.0	<0.001	<0.001	<0.001
	Iron	0.01	mg/l	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	3,300.0	<0.01	<0.01	<0.01
	Lead	0.001	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	15.0	<0.001	<0.001	<0.001
	Manganese	0.001	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	45.0	<0.001	<0.001	<0.001
	Mercury	0.0001	mg/l	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.5	<0.0001	<0.0001	<0.0001
	Molybdenum	0.001	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.162	<0.5	<0.001	<0.001	<0.001
	Nickel	0.001	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.5	<0.001	<0.001	<0.001
	Strontium	0.001	mg/l	9.18	9.37	9.47	9.32	9.29	9.28	9.23	9.38	98.7	<0.5	9.5	9.78	9.46
	Vanadium	0.01	mg/l	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.5	<0.01	<0.01	<0.01
	Zinc	0.005	mg/l	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.054	<0.5	<0.005	<0.005	<0.005
Nutrients	Nitrate as N	0.01	mg/l	0.02	0.02	0.01	<0.01	<0.01	0.02	0.04	0.01	<0.01	<0.5	<0.01	<0.01	<0.01
	Nitrite as N	0.01	mg/l	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.5	<0.01	<0.01	<0.01
	Reactive Phosphorus	0.01	mg/l	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	<0.5	<0.01	<0.01	<0.01

[26] Results highlighted in red indicate a breach of one or more of the guideline values highlighted in **Appendix 9C**. Results in green indicate compliance. Results with no highlight indicate that no guideline has been identified for the parameter.

Parameter		LOR	Unit	Station and AOI												
				AOI 1								AOI 2		AOI 3		
				BMP 10	BMP 20	BMP 22	BMP 26	BMP 33	BMP 35	BMP 43	BMP 45	M1	M2	SW 08	SW 22	SW 24
	as P															
	Total Phosphorus as P	0.01	mg/l	0.42	0.47	0.19	0.19	0.13	0.19	0.34	0.38	0.22	<0.5	0.10	0.21	0.01
Major Cations and Anions	Calcium (Ca)	0.0	mg/l	568.0	581.0	571.0	565.0	576.0	570.0	579.0	568.0	593.0	<0.5	543.0	562.0	562.0
	Magnesium (Mg)	1.0	mg/l	1,810.0	1,840.0	1,830.0	1,800.0	1,830.0	1,840.0	1,830.0	1,820.0	1680.0	<0.5	1,540.0	1,590.0	1,600.0
	Potassium (K)	1.0	mg/l	738.0	786.0	751.0	768.0	784.0	752.0	751.0	737.0	770.0	<0.5	720.0	753.0	752.0
	Sodium (Na)		mg/l	15,300.0	15,600.0	15,500.0	15,300.0	15,600.0	15,600.0	15,500.0	15,200.0	15,200.0	<0.5	13,200.0	13,600.0	13,700.0
Total Petroleum Hydrocarbons (TPH)	C6-C9 Fraction	20.0	µg/l	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0	<0.5	<20.0	<20.0	<20.0
	C10-C14 Fraction	50.0	µg/l	<50.0	<50.0	<50.0	<50.0	<50.0	<50.0	<50.0	<50.0	<50.0	<0.5	<50.0	<50.0	<50.0
	C15-C8 Fraction	100.0	µg/l	<100.0	<100.0	<100.0	<100.0	<100.0	<100.0	<100.0	<100.0	<100.0	<0.5	<100.0	<100.0	<100.0
	C29-C36 Fraction	50.0	µg/l	<50.0	<50.0	<50.0	<50.0	<50.0	<50.0	<50.0	<50.0	<50.0	<0.5	<50.0	<50.0	<50.0
	C37-C40 Fraction	50.0	µg/l	<50.0	<50.0	<50.0	<50.0	<50.0	<50.0	<50.0	<50.0	<50.0	<10.0	<50.0	<50.0	<50.0
	Sum of C10 – C40 Fraction	100.0	µg/l	<100.0	<100.0	<100.0	<100.0	<100.0	<100.0	<100.0	<100.0	<100.0	<50.0	<100.0	<100.0	<100.0

9.5 Hydrodynamic Results

9.5.1 Plume Footprints

The model results are presented in 'footprint' plots as time-averages. There is a period of a week centred on the spring tide, and a period of a week centred on the neap tide. The average and maximum values are presented for each period.

Thermal discharges in Bahrain are assessed in terms of the existing Bahrain Temperature Standard (BSIE), which 'limits' the size of a +3°C mixing zone to 100 m (maximum value). However, Ministerial Order No. 2 of 2001 amending certain provisions of Order No. 10 of 1999 with respect to environmental standards (air and water) states in Article 22 (bis):

"*The Environment Authority may define the mixing area of certain projects with more or less than a circle or semi-circle with a diameter of one hundred (100) metres, as the case may be, and in view of the location, type and characteristics of the discharged water. The Environment Authority map compel the projects which do not accept such definition or wishes to modify their mixing area or have been defined before, to carry out such task and at their own expenses to conduct a study or more by a specialised firm of consultants approved by the Environment Authority to define the mixing point for such projects and determine the effect of discharging the waste water is such area. The definition resulting from this study shall be final*."

The IFC standard (World Bank, 2007) is similar to the BSIE and states the following: "*Temperature of wastewater prior to discharge does not result in an increase greater than 3°C of ambient temperature at the edge of a scientifically established mixing zone which takes into account ambient water quality, receiving water use and assimilative capacity among other considerations*."

For the average discharge (**Table 9.3**), weekly-average excess temperatures are predicted to be greater than 3°C over most of the bay between the Bapco intake and the Yacht Club, and greater than 5°C for the summer and winter discharges (see **Tables 9.9** – **9.11**). The predicted maximum excess temperatures are above 5°C over almost all of this area at the sea surface, for all conditions tested. At the seabed, maximum excess temperatures are more than 5°C for around half of this area.

For the average discharge with typical wind, the average excess temperature falls to 3°C around 750 m from the main outfall, at the sea surface, on spring tides, and around 1,000 m on neap tides. As the predicted, the Bapco outfall mixing zones extend further than 100 m from point source; the total average and maximum areas of the sea surface and seabed where excess temperatures are greater than +3°C has also been presented (**Table 9.9** - **Table 9.11**)[27].

In general, weaker winds result in larger plume footprints due to the reduction in cooling to the atmosphere. The plume footprints are largest at the sea surface during summer, as the discharge excess temperature is highest. Neap tides generally result in larger plume footprints due to the reduction in mixing and dilution. The areas where average

[27] These present the areas and distances from the outfall at the sea surface and seabed where the average and maximum temperatures are predicted to be above 3°C.

excess temperature is greater than 3°C are around 0.3 km^2 at the seabed and around 0.5 km^2 at the sea surface. These areas extend up to around 700 m from the outfall at the seabed and 1,100 m at the sea surface.

Figure 9.2 highlights the excess temperature footprints for the summer discharge with weak wind conditions at the surface whilst **Figure 9.3** highlights excess temperature footprints for the summer discharge with weak wind conditions at the seabed. The remainder of the excess temperature footprints can be found in **Appendix 9B**.

Table 9.9 Areas and Distances from Outfall where Excess Temperature is predicted to be above 3°C, Summer Discharge

Conditions		Area - km²		Distance - m		Area - km²		Distance - m	
		Weak wind		Weak wind		Typical wind		Typical wind	
		Mean	Maximum	Mean	Maximum	Mean	Maximum	Mean	Maximum
Sea surface	Spring	0.53	1.60	1,100	1,700	0.39	1.32	900	1,500
	Neap	0.55	1.86	1,100	1,800	0.55	1.85	1,100	1,800
Seabed	Spring	0.34	0.65	700	700	0.27	0.68	700	700
	Neap	0.34	0.79	700	800	0.35	0.77	700	900

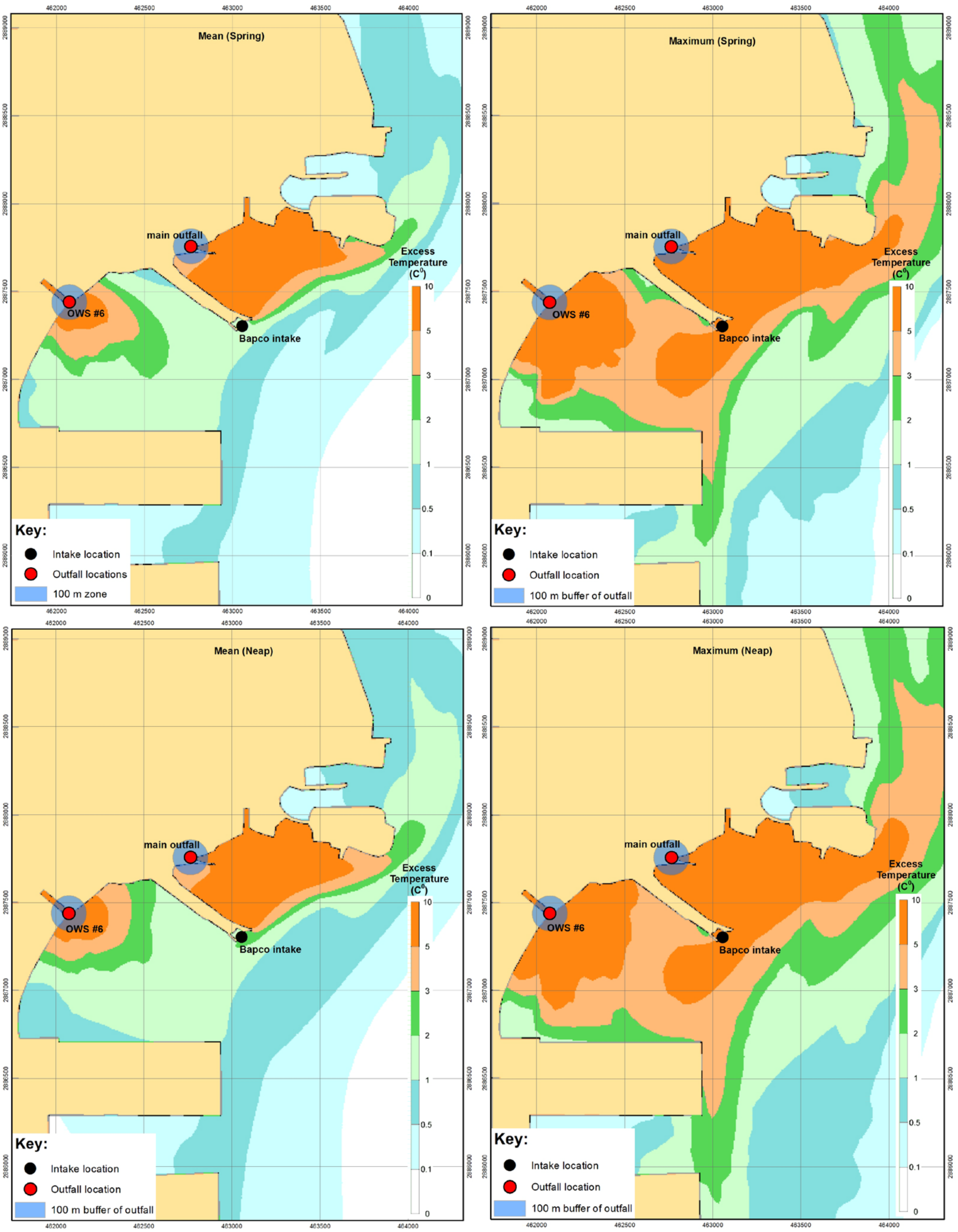
Table 9.10 Areas and Distances from Outfall where Excess Temperature is predicted to be above 3°C, Winter Discharge

Conditions		Area - km²		Distance - m		Area - km²		Distance - m	
		Weak wind				Typical wind			
		Mean	Maximum	Mean	Maximum	Maximum	Maximum	Mean	Maximum
Sea surface	Spring	0.50	1.26	1,000	1,400	0.36	1.20	700	1,300
	Neap	0.53	1.50	1,000	1,500	0.51	1.56	1,100	1,500
Seabed	Spring	0.34	0.69	700	700	0.29	0.77	600	700
	Neap	0.36	0.88	700	1,000	0.36	0.85	700	900

Table 9.11 Areas and Distances from Outfall where Excess Temperature is predicted to be above 3°C, Average Discharge

Conditions		Area - km²		Distance - m		Area - km²		Distance - m	
		Weak wind				Typical wind			
		Mean	Maximum	Mean	Maximum	Mean	Maximum	Mean	Maximum
Sea surface	Spring	0.45	1.19	1,000	1,300	0.30	1.11	700	1,300
	Neap	0.47	1.40	1,000	1,500	0.46	1.45	1,000	1,500
Seabed	Spring	0.28	0.61	700	700	0.23	0.66	500	700
	Neap	0.31	0.75	700	800	0.32	0.74	700	900

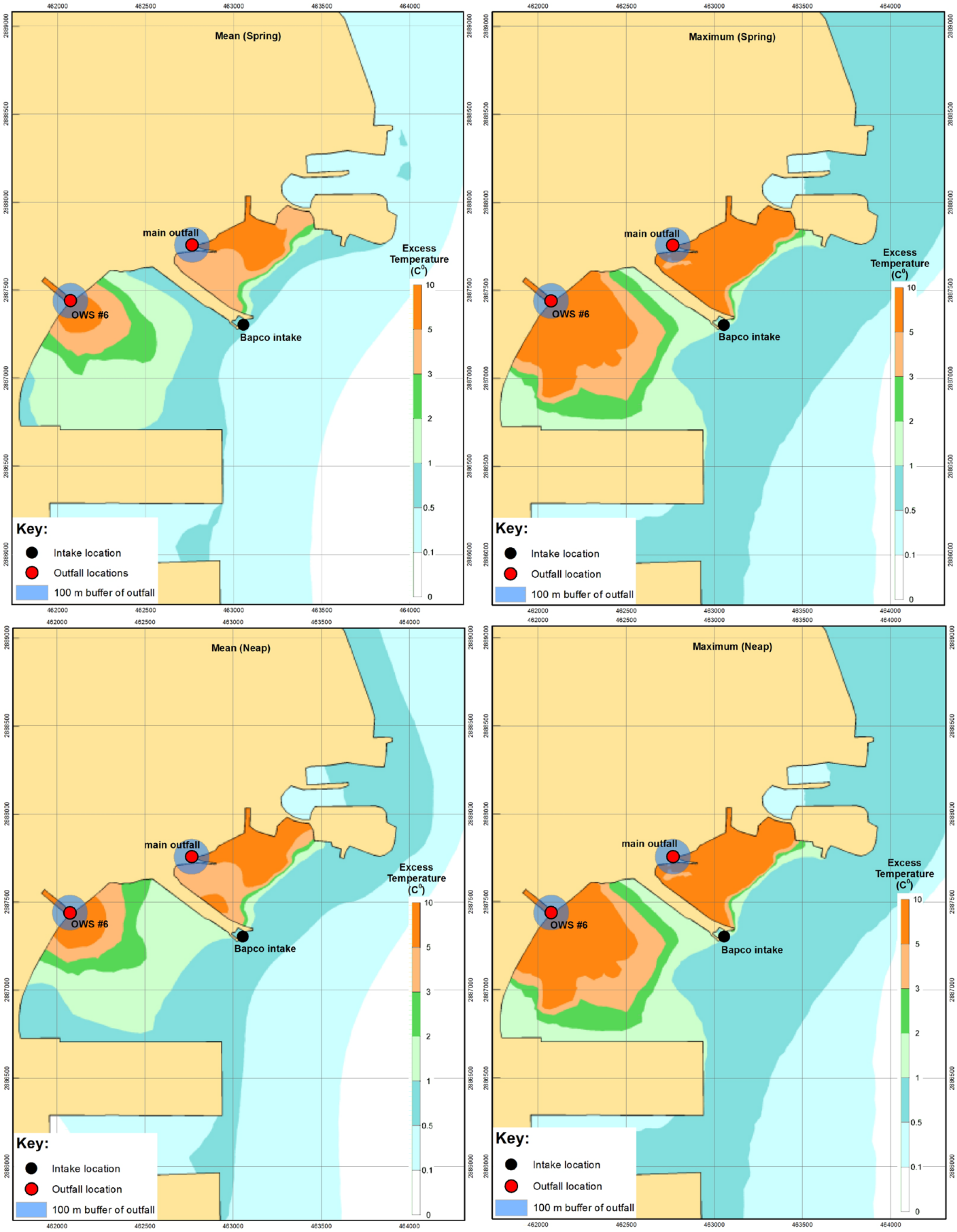
Figure 9.2 Excess Temperature Footprints for Summer Discharge, Weak Wind Conditions, Surface



Title: Excess Temperature Footprints for Summer Discharge, Weak Wind Conditions, Surface			Client: Bapco, Technip
Project: Bapco Modernization Program			
Date: May 2016	Figure No.: 9.2		Consultant: Environment Arabia
Datum: WGS 84 - UTM 39N	Scale: 1:20,000		

CN:\Bapco Modernisation Plan\mxd\marine\hydromod\summer surface seabed\summer surface.mxd

Figure 9.3 Excess Temperature Footprints for Summer Discharge, Typical Wind Conditions, Seabed



Title: **Excess Temperature Footprints for Summer Discharge, Typical Wind Conditions, Seabed**			Client: Bapco Technip
Project: Bapco Modernization Program			
Date: May 2016	Figure No.: 9.3		Consultant: Environment Arabia
Datum: WGS 84 - UTM 39N	Scale: 1:20,000		

CN:\Bapco Modernisation Plan\mxd\marine\hydromod\summer surface seabed\summer seabed.mxd

9.5.2 Recirculation Temperatures

Predicted excess temperatures at the Bapco intake were extracted from the model. Time history plots are shown in the Appendix B of the standalone report (**Appendix 9B**) and show considerable variation over time with peak excess temperatures up to 6°C predicted at the sea surface.

Tables 9.12 - **Table 9.14** show the average and maximum values for all simulations. There is a noticeable variation of temperature recirculation through the water depth, with peak surface temperatures up to 3°C warmer than the seabed. The intake will draw from the full water column, and so the depth-average is likely to be most representative of the actual temperature of water entering the plant. The time-averaged recirculation temperature is found to be around 1°C for all conditions studied, and the instantaneous (depth-averaged) excess temperature is below 1°C most of the time.

Recirculation temperatures are predicted to be slightly higher in winter than summer. This is probably because the higher ambient water temperatures in summer (combined with the slightly larger footprint at the sea surface) produce greater heat loss to the atmosphere.

Table 9.12 Excess Temperatures at the Bapco Intake (°C), Summer Discharge

Conditions	Weak wind		Typical wind	
	Mean	Maximum	Mean	Maximum
Surface	1.7	6.2	1.5	6.1
Mid-depth	0.8	2.9	0.9	3.8
Bed	0.7	1.5	0.7	2.2
Depth-average	1.1	3.3	1.0	4.0

Table 9.13 Excess Temperatures at the Bapco Intake (°C), Winter Discharge

Conditions	Weak wind		Typical wind	
	Mean	Maximum	Mean	Maximum
Surface	1.7	6.0	1.5	6.3
Mid-depth	1.0	3.5	1.0	4.5
Bed	0.8	1.9	0.8	2.9
Depth-average	1.1	3.6	1.1	4.5

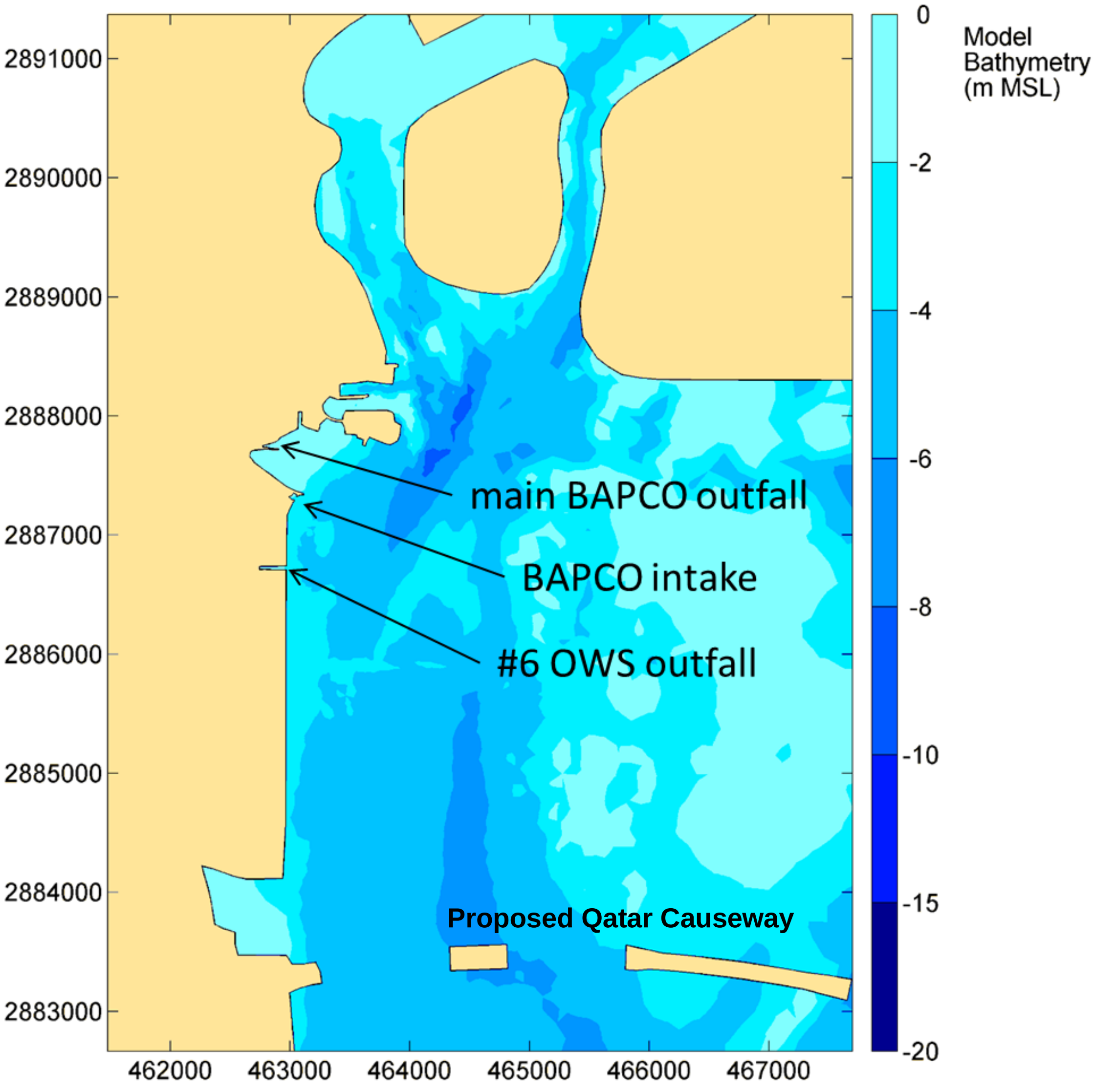
Table 9.14 Excess Temperatures at the Bapco Intake (°C), Average Discharge

Conditions	Weak wind		Typical wind	
	Mean	Maximum	Mean	Maximum
Surface	1.5	5.7	1.4	5.8
Mid-depth	0.9	3.1	0.9	4.1
Bed	0.6	1.5	0.7	2.5
Depth-average	1.0	3.2	1.0	4.1

9.5.3 Bahrain 2030 NPDS Layout

Figure 9.4 provides the Bahrain 2030 NPDS layout in the Bapco Area. It can be seen that the OWS#6 outfall is completely covered (i.e. the plan suggests this area will be reclaimed), and thus the position of the outfall has been moved to the nearest location that meets the sea.

Figure 9.4 2030 NPDS Layout, Bapco Area



Plume footprints and recirculation temperature time series for the average discharge are shown in the Appendix D of **Appendix 9B**. **Table 9.15** shows the average and maximum areas where the excess temperature is predicted to be above 3°C. These are smaller than for the existing layout, which is primarily because the OWS#6 discharge disperses more rapidly from its new location. The general extent of the main cooling water plume is similar to that in the existing case.

Table 9.16 shows the predicted average and maximum recirculation excess temperatures. These are similar to, or lower than, the existing values. The presence of the new reclamation to the south of the Bapco intake (as included in the model) reduces the size of the eddy that forms in Farisiyah Bay. This reduces the transport of the plume towards the intake on the southward phase of the tide.

Table 9.15 Areas where Excess Temperature is Predicted to be Above 3°C, Average Discharge, 2030 Layout

Conditions		Area - km^2		Distance from source - m		Area - km^2		Distance from source - m	
		Weak wind		Weak wind		Typical wind		Typical wind	
		Mean	Maximum	Mean	Maximum	Mean	Maximum	Mean	Maximum
Sea surface	Spring	0.37	0.80	1,000	1,500	0.28	0.74	700	1,700
	Neap	0.41	0.90	1,000	1,500	0.4	0.90	1,000	1,500
Seabed	Spring	0.19	0.24	700	700	0.18	0.26	500	700
	Neap	0.21	0.27	700	700	0.22	0.26	700	700

Table 9.16 Excess Temperatures at the Bapco Intake (°C), Average Discharge, 2030 Layout

Conditions	Weak wind		Typical wind	
	Mean	Maximum	Mean	Maximum
Surface	1.5	5.2	1.3	4.7
Mid-depth	0.7	3.2	0.8	3.7
Bed	0.4	2.1	0.5	2.3
Depth-average	0.8	3.3	0.9	3.6

9.5.4 Conservative Tracers

The model simulations included a conservative (that is, non decaying) tracer discharged at unit concentration from the main and OWS#6 outfalls. These concentration fields can be used to estimate the diluted concentrations of any dissolved chemical that may be present in the discharges – assuming that the background concentration of the constituent is zero.

For example, if the plots indicate that the tracer concentration is 0.5 at a site of particular interest, the concentration of a chemical discharged at 1 g/l will be approximately 0.5 g/l, neglecting any decay or reactions. Over short timescales and distances, this can give an approximation of the concentrations of many discharge constituents (e.g. dissolved metals or residual chlorine).

As such, the conservative tracers have been calculated for the post BMP scenario for a selection of dissolved chemical parameters highlighted in the BSIE[28].

Tables 9.17 – **9.19** show the areas and distances from the outfall where the average and maximum tracer concentrations are predicted to be above 0.9 (90%), 0.5 (50%), and 0.1 (10%) of the discharge concentration for the summer discharge. For the other conditions tested, the areas and distances are slightly smaller.

Table 9.20 provides examples of predicted values for select nutrients and metals as a conservative tracer based on the average monthly (starting) values highlighted in the BSIE. The values in **Table 9.20** have been highlighted in either red (indicates a predicted value is greater than most stringent guideline highlighted in **Appendix 9C**), or in green (indicate predicted value is less than most stringent guideline value highlighted in **Appendix 9C**).

It should be noted that the predicted values, as determined by the conservative tracer, are likely to be higher than what would be recorded in the field as they are based on a background level of zero, which is not necessarily true for all parameters (see **Section 9.4**, baseline water quality). In addition, dissolved parameters in the water column (e.g. nutrients) are likely to degrade over time or can be taken up / utilised by organisms.

The information is presented as it may assist in determining suitable mixing zones and further inform national planners for future planned land/sea use.

Figure 9.5 highlights the average footprints of the conservative tracer relative concentration for the summer discharge under typical wind conditions.

[28] These are in line with predicted effluent quality post BMP. It should be noted that this is a conservative approach to the analysis.

Table 9.17 Areas and Distances from Outfall where Conservative Tracer Concentration is Predicted to be above 0.9 (90%) of the Discharge Concentration, Summer Discharge

Conditions		Area - km^2		Distance - m		Area - km^2		Distance - m	
		Weak wind		Weak wind		Typical wind		Typical wind	
		Mean	Maximum	Mean	Maximum	Mean	Maximum	Mean	Maximum
Sea surface	Spring	0.1	0.60	500	700	0.05	0.56	400	700
	Neap	0.17	0.82	600	800	0.15	0.81	700	900
Seabed	Spring	0.02	0.46	300	600	0.02	0.50	300	700
	Neap	0.07	0.70	500	800	0.06	0.67	500	900

Table 9.18 Areas and Distances from Outfall where Conservative Tracer Concentration is Predicted to be above 0.5 (50%) of the Discharge Concentration, Summer Discharge

Conditions		Area - km^2		Distance - m		Area - km^2		Distance - m	
		Weak wind		Weak wind		Typical wind		Typical wind	
		Mean	Maximum	Mean	Maximum	Mean	Maximum	Mean	Maximum
Sea surface	Spring	0.70	1.43	900	1,400	0.46	1.31	700	1,400
	Neap	0.88	1.61	1,000	1,500	0.67	1.63	1,000	1,500
Seabed	Spring	0.49	0.92	700	1,100	0.34	0.94	500	900
	Neap	0.68	1.04	800	1,100	0.49	1.01	700	1,100

Table 9.19 Areas and Distances from Outfall where Conservative Tracer Concentration is Predicted to be above 0.1 (10%) of the Discharge Concentration, Summer Discharge

Conditions		Area - km^2		Distance - m		Area - km^2		Distance - m	
		Weak wind		Weak wind		Typical wind		Typical wind	
		Mean	Maximum	Mean	Maximum	Mean	Maximum	Mean	Maximum
Sea surface	Spring	2.16	7.22	1,900	5,000	1.91	7.09	1,900	5,500
	Neap	3.31	11.59	3,100	6,400	3.18	11.36	2,300	5,900
Seabed	Spring	1.47	4.89	1,900	5,000	1.55	5.92	1,900	5,400
	Neap	2.18	9.59	2,700	6,400	2.10	9.41	2,200	5,800

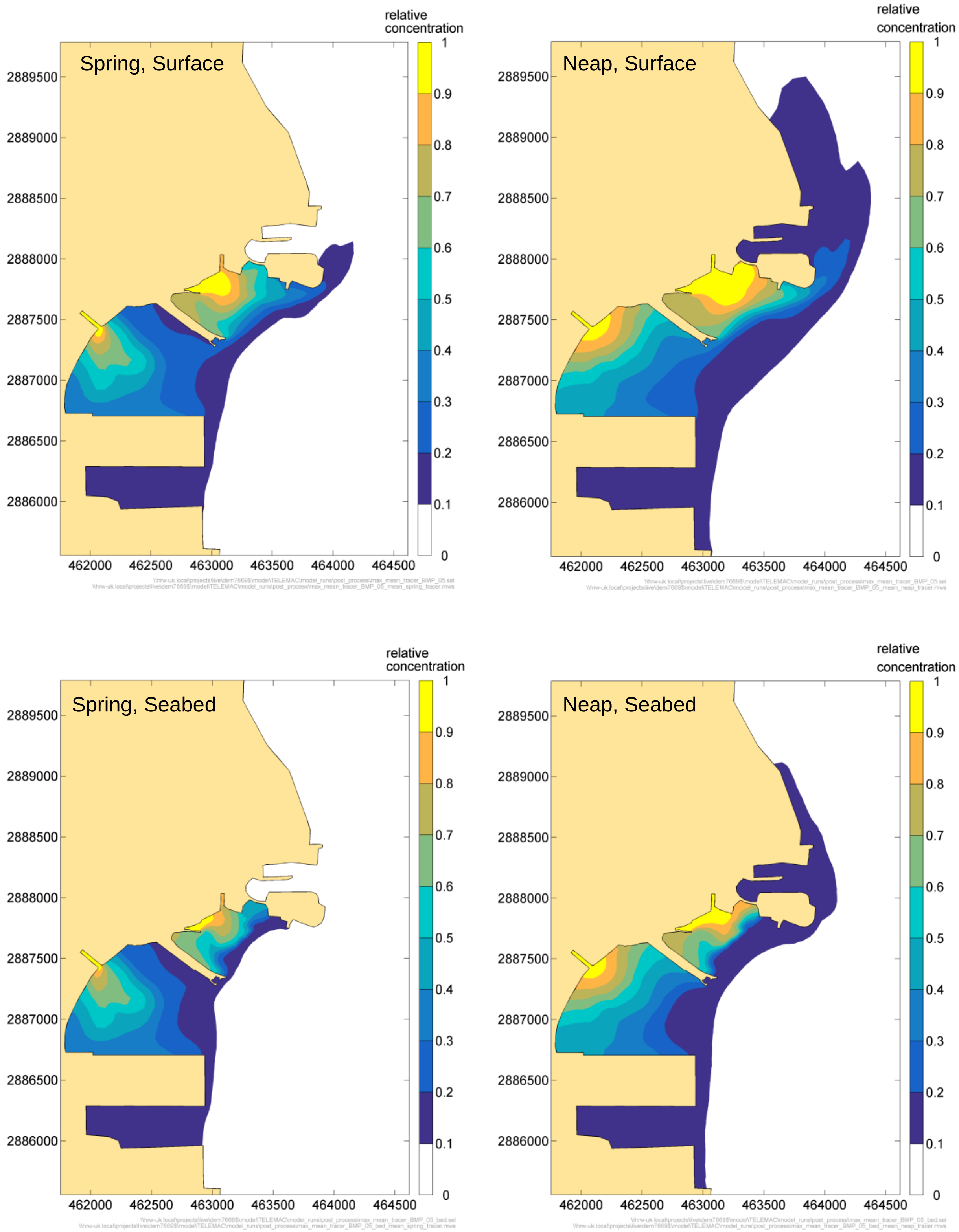
Table 9.20 Examples of Predicted Values for Select Nutrients and Metals as a Conservative Tracer

Parameter	Value at source (mg/l)[29]	Value at '0.9' contour (mg/l)	Value at '0.5' contour (mg/l)	Value at '0.1' contour (mg/l)
Nitrate (NO_3)	0.01	0.009	0.005	0.001
Nitrite (NO_2)	0.001	0.0009	0.0005	0.0001
Aluminium	1	0.9	0.5	0.1
Cadmium	0.1	0.009	0.05	0.01
Chromium total	0.1	0.009	0.05	0.01
Copper	0.1	0.009	0.05	0.01
Iron	0.1	0.009	0.05	0.01
Lead	0.1	0.009	0.05	0.01
Mercury	0.002	0.0018	0.001	0.0002
Nickel	0.1	0.009	0.05	0.01
Zinc	0.1	0.009	0.05	0.01

Key: Red highlight – predicted value is greater than most stringent guideline highlighted in **Appendix 9C**. Green highlight – predicted value is less than most stringent guideline value highlighted in **Appendix 9C**. No highlight (white) – predicted value is equal to most stringent guideline value highlighted in **Appendix 9C**.

[29] Derived from the average value presented in the BSIE.

Figure 9.5 Average Footprints of Tracer Relative Concentration for Summer Discharge, Typical Wind



9.6 Impact Assessment

9.6.1 Impacts during Construction

Detailed construction method statements are yet to be developed, however, consultation with both Bapco and Technip, previous project experience, and expert knowledge suggests the following impacts are likely to arise from construction activities. The following sections present these per AOI and based on the following key activities:

- Construction and operation of labour camps and laydown areas in AOI 1.
- Reclamation of temporary workspace in Ma'ameer channel (AOI 2).
- Removal of existing and construction of new pipeline crossing in Ma'ameer (AOI 2).
- Installation of new sealines in AOI 3.
- General construction and onshore civil works with potential discharges of effluents to sea (all areas).

Table 9.21 provides a summary of the impact assessment for the construction phase.

9.6.1.1 Discharge of Sewage Effluent from Labour Camps

AOI 1

During construction, there is a potential that treated sewage effluent arising from the labour camps on site, shall be discharged into Farisiyah Bay. Wastewater and sewage from labour camps has been estimated as 2,000,000 m^3; as total for the whole project.

Bapco has indicated that sewage will undergo biological treatment (treated in package sewage treatment plants) and the wastewater allowed to pass through the settlement tanks of the Waste Water Treatment Plant (WWTP). The fate of the TSE is unknown at this stage; however should the effluent be discharged to sea, it would have to be compliant with the MWMAUP “TSE standards for agriculture unrestricted reuse and discharge to sea – sensitive areas” (**Appendix 9C**), and be permitted by the SCE. This may require additional studies (e.g. dispersion modelling) in order to quantify the impact. Such studies would need to take into account the effect, if any, of the existing discharge of heated effluent. As this issue has not been studied as part of this commission, it is not possible to assign an impact.

AOI 2 and AOI 3

There are no planned discharges of sewage in either area. Site ablution facilities would be provided on site with wastes tankered off and disposed at an approved sewage treatment facility. **No impact** is assigned.

9.6.1.2 Terrestrial Dewatering - Introduction of Fines and Contaminants to Seawater

AOI 1 and AOI 2

Works within the BMP site and Ma’ameer Channel may require excavation below the water table and subsequent dewatering works with wastewaters discharged to sea. This will require a permit from the SCE.

It is standard practice that effluents are first dewatered within a settlement tank(s) so that any suspended particles are removed prior to discharge. Contractors are required to ensure that effluents meet national standards (BSIE) and this will require monitoring for specific parameters as defined in **Appendix 9C**; this is of particular importance given the risk that groundwater may exhibit signs of historic contamination events (e.g. hydrocarbons).

A **minor adverse** impact is conservatively assigned in this regard for both areas should wastewaters meet the BSIE.

<u>AOI 3</u>

Terrestrial dewatering is not anticipated in this area. **No impact** is assigned.

9.6.1.3 Surface Water Run off

<u>AOI 1 and AOI 2</u>

With construction and operation of labour camps, and laydown areas close to the shoreline of AOI 1, the potential exists for surface water runoff discharging to the marine environment from hard standings containing deposited airborne contaminants, surface greases/oils/fuels, and/or wash waters from concrete casting (AOI 1 & 2). Best practice mitigation is to be implemented to prevent discharges to sea unless permitted by the SCE and which adhere to the BSIE.

A **minor adverse** impact is conservatively assigned in this regard for both areas should waste waters meet the BSIE.

<u>AOI 3</u>

As construction works are sub-sea, no waste water run of is anticipated other than unplanned discharges/spillages from construction vessels to sea. **No impact** is assigned.

9.6.1.4 Spillages of Fuels, Chemicals and Wastes

Construction works will require fuels to be stored at worksites/vessels and the potential exists that spillages may occur throughout the duration of works. Given that works in the marine environment are limited in scope and largely restricted to AOI 2 and AOI 3, the later which will require marine vessels, impacts upon water quality can be considered limited.

<u>AOI 1</u>

No construction works are to take place within this area, hence **no impact** is assigned.

AOI 2

Limited fuel supplies are likely to be stored onsite, hence the potential for spillages to enter the channel exist. Given the expected small volumes stored (i.e. <1000 litres), and incorporation of best practice guidance/mitigation (**Section 9.7**), impacts upon water quality are expected to be **negligible**.

AOI 3

Operation of marine vessels associated with pipeline installation will be required to adhere to national and Bapco marine vessel regulations. Currently, details are not available of the type and size of vessels, however, existing regulations (Ship Oil Pollution Emergency Plan - SOPEP) require appropriate plans should be in place for any vessel >400 GT in the event of an oil spill.

Diesel fuel is a light, refined petroleum product with a relatively narrow boiling range, meaning that, when spilled on water, most of the oil will evaporate or naturally disperse rapidly. It has a very low viscosity and is readily dispersed into the water column/evaporated following agitation due to wave and wind action.

Given the likelihood and magnitude of such an event, an impact on water quality is assigned as **minor adverse**.

9.6.1.5 Impact of Construction Operations on Existing Seawater Intakes

In the context of water quality and hydrodynamics, sensitive receptors are considered to be intakes.

AOI 1

Despite the Bapco intake being present within the study area, no construction activities are proposed to take place as part of the BMP, hence **no impacts** are identified.

AOI 2

In the Ma'ameer Channel, works are anticipated to be too far away from any sensitive receptors (Bapco intake, GPIC intake) to have any potential impact on the intakes. In addition to the geographical impediment, the risk of impact on sensitive receptors is further made implausible if the mitigation highlighted in **Section 9.7.1** is conducted; **no impact** is assigned.

AOI 3

The proximity of the works in the Sitra Warf area are considerably closer to the Alba intake (approximately 600 m) and thus appropriate mitigation and monitoring is required (**Section 9.7**). Plume dispersion modelling has not been carried out, as method statements for works are yet to be determined, regardless, best practice requires that appropriate controls be put in place. An impact cannot be assigned at this stage.

Table 9.21 Impact Summary Table – Marine Construction Activities

Description of Impact	AOI	Receptor sensitivity	Features of impact				Type of impact (D,I)	Impact Significance	Residual Impact (following mitigation)
			Magnitude	Extent	Duration	Likelihood			
Discharge of Sewage Effluent from Labour Camps	AOI 1	H	-	Lo	T	Li	D,I	Not possible to assign an impact	-
	AOI 2		-	-	-	-	-	-	-
	AOI 3		-	-	-	-	-	-	-
Terrestrial Dewatering - Introduction of Fines and Contaminants to Seawater	AOI 1	H	N	Lo	T	Li	D,I	Minor Adverse	Negligible/ Minor Adverse
Surface Water Run off	AOI 1	H	N	Lo	T	Li	D,I	Minor Adverse	Negligible/ Minor Adverse
	AOI 2		N	Lo	T	Li	D,I	Minor Adverse	Negligible/ Minor Adverse
	AOI 3		-	-	-	-	-	-	-
Spillages of Fuels, Chemicals and Wastes	AOI 1	H	-	-	-	-	-	-	-
	AOI 2		N	Lo	T	U	D	Negligible	Negligible
	AOI 3		N	Lo	T	U	D	Minor Adverse	Negligible
Impact of Construction Operations on Existing Seawater Intakes	AOI 1	H	-	-	-	-	-	-	-
	AOI 2		-	-	-	-	-	-	-
	AOI 3		-	-	-	-	-	Not possible to assign an impact	-

LT–long term, L-low, H-high, N-negligible, Lo-local, T–temporary, M-medium, De-definite, U-unlikely, D-direct, I-indirect, Li-likely, "-" – No values assigned / does not occur

9.6.2 Impacts during Operation

Table 9.22 provides a summary of the impact assessment for the operation phase.

9.6.2.1 Impact of Operational Regime on Water Quality

<u>AOI 1</u>

Changes to the operational regime are detailed in **Section 2**. Estimates of seawater intake rates before and after the BMP are shown in **Table 2.2** (716,132 m^3/d under normal capacity post BMP in comparison to 752,232 m^3/d at present). The temperature differential post BMP is as per the input parameters for the modelling (average excess temperature of 11.0 °C from the main outfall and average excess temperature of 8.5 °C from OWS#6 outfall).

It is evident that although the capacity of the Refinery will be increased post-BMP, the amount of seawater used will be slightly reduced. This is due to the inclusion of an indirect, closed-loop cooling water system with cooling towers rather than a single pass cooling system post BMP which increases the efficiency of the plant overall. In addition, although the BMP will introduce several new effluent streams, whilst retiring several existing ones, overall the BMP is not expected to significantly change the composition, temperature or volume of the effluents.

As it was reported that there will be no significant changes to the quality and volume of the effluent post BMP, hence the modelling works used the existing (baseline) conditions to represent the conditions post BMP. The BMP will therefore have a **negligible** impact on existing water quality in AOI 1.

<u>AOI 2</u>

Routine operation, post BMP, will have **no impact** on marine water quality within the Ma'ameer Channel, as there will be no activity or releases at this location.

<u>AOI 3</u>

Routine operation post BMP will have **no impact** on marine water quality within the Sitra Wharf area, as there are no sources of input into the marine environment from planned operations.

9.6.2.2 Impact of Operational Regime on Plume Dispersion

<u>AOI 1</u>

Section 9.5.1 highlights the plume dispersion footprint of the effluent from the Refinery. For the average discharge with typical wind the average excess temperature falls to 3°C around 750 m from the main outfall at the sea surface on spring tides, and around 1,000 m on neap tides.

It is clear that the thermal plume arising from both the existing and post BMP scenarios do not meet the basic 100 m mixing zone requirement identified in the BSIE. It should be noted that the Ministerial Order No. 3 of 2001, from which the BSIE originate does

Table 9.22 Impact Summary Table – Routine Operation Post-BMP

Description of Impact / scenario	AOI	Receptor sensitivity	Features of impact				Type of impact (D,I)	Impact Significance	Residual Impact (following mitigation)
			Magnitude	Extent	Duration	Likelihood			
Impact of Routine Operation Post BMP on Water Quality	AOI 1	H	N	Lo	LT	Li	D	Negligible	Negligible
	AOI 2		-	-	-	-	-	No Impact	-
	AOI 3		-	-	-	-	-	No Impact	-
Impact of Operational Regime on Plume Dispersion	AOI 1	H						Not possible to assign an impact	
	AOI 2		-	-	-	-	-	No Impact	-
	AOI 3		-	-	-	-	-	No Impact	-
Impact of Bahrain 2030 NPDS Layout on the Operational Regime (extent of Plume and Recirculation Temperatures)	AOI 1	H						Minor Adverse	Not possible to assign an impact
	AOI 2		-	-	-	-	-	No Impact	-
	AOI 3		-	-	-	-	-	No Impact	-
Impact of Operational Discharge on Seawater Intakes	AOI 1	H	N	Lo	LT	Li	I	Negligible	Negligible
	AOI 2		-	-	-	-	-	No impact	-
	AOI 3		-	-	-	-	-	No impact	-

LT–long term, L-low, H-high, N-negligible, Lo-local, T–temporary, M-medium, De-definite, U-unlikely, D-direct, I-indirect, Li-likely, "-" – No values assigned / does not occur recognize that larger mixing zones may be used based on the results of specialist studies. This approach to defining the extent of a mixing zone based on the dispersion characteristics of the study area is similar to that identified in World Bank General EHS Guidelines.

The impact of the thermal plume on marine ecology is discussed further in **Section 11**. This is the key determining factor in describing the impact of the thermal plume as higher water temperatures around the outfalls may distort the natural ecosystem by favouring thermally tolerant species.

<u>AOI 2 and AOI 3</u>

During routine operation, there are no discharges to the marine environment in either area, hence **no impact** is assigned.

9.6.2.3 Impact of Bahrain 2030 NPDS Layout on the Operational Regime (extent of Plume and Recirculation Temperatures) (AOI 1 only)

Section 9.5.3 provides the results of the modelling exercise for the 2030 layout. The proposed 2030 layout showed relatively small changes to the plume dispersion (i.e. low magnitude). The predicted plume footprints are smaller than for the existing layout; the #6 OWS discharge disperses more rapidly. The general extent of the main cooling water plume is similar to that in the existing case. Recirculation temperatures at the Bapco intake are predicted to be slightly lower after development, due to the changes in local current patterns around the intake. Based on the aforementioned summary, the predicted impacts of the development plan on the planned discharge are assigned as **minor** according to the 2030 layout modelled[30].

<u>AOI 2 and AOI 3</u>

During routine operation, there are no discharges to the marine environment in either area, hence **no impact** is assigned.

9.6.2.4 Impact of Operational Discharge on Seawater Intakes

<u>AOI 1</u>

The potential for post BMP thermal plumes to adversely affect existing seawater intakes, including recirculation to the Bapco intake, is discussed in **Section 9.5.2**.

For the Bapco intake, the time-averaged recirculation temperature is found to be around 1°C for all conditions studied, and the instantaneous (depth-averaged) excess temperature is below 1°C most of the time. Consultation with Bapco has indicated that these levels are considered **negligible**.

Other intakes (e.g. GPIC) are located several kilometres away from the study area and modelling shows that thermal plumes fall short of their location by several kilometres. **No impact** is assigned.

[30] Note this actually assesses the 2030 coastal configuration on the outfall.

AOI 2 and 3

During routine operation, there are no discharges to the marine environment in either area, hence **no impact** to third party intake facilities.

9.7 Mitigation and Monitoring

9.7.1 Mitigation and Monitoring During Construction

9.7.1.1 Discharge of Treated Sewage Effluent (TSE)

- Ensure any discharges of effluents to sea are first permitted by the SCE. It is likely they will require additional specialist studies to assess impacts.
- Consult with the Sanitary Engineering Operations and Maintenance Directorate (SEOMD) of the MWMAUP to assess the potential to discharge to existing sewers and/or wastewater treatment plants.

9.7.1.2 General Site Dewatering

- Identify any permanent dewatering facility from the outset. Mobile discharges to be identified as they come online.
- Where there is a potential for effluents to be contaminated, first conduct sampling and laboratory analysis for prime constituents.
- Discharge to sea requires a permit from the SCE. Such a permit is likely to be in the form of a conditional no objection letter but will only address general site de-watering.
- Discharge to municipal sewer requires a permit from the SEOMD.
- Appropriate use of settlement tanks/ponds. Ensure that settlement tanks are regularly maintained (i.e. accumulated sediments removed) and that effluents are monitored appropriately.
- If there are any de-watering works required, the contractor is advised of the requirement to ensure that 'waste' water is first passed through a settlement tank(s); TSS of waters is not to exceed a monthly average of 20 mg/l or a single maximum event of 35 mg/l[31]. Ensure that settlement tanks are regularly inspected and that accumulated fines are removed and disposed at a suitable location; they are not to be dumped.
- Discharge to sewer not to exceed 500 mg/l. A relevant permit must be obtained prior to any discharges.
- Should TSS limits be exceeded, then actions must be taken to manage the dewatering more effectively (i.e. allowing increased settling of fines within the entrapment area).

9.7.1.3 Surface Water Runoff

- Ensure that a drainage collection system is installed for all hard standing areas, particularly around work site areas where there is a potential for operational spillages of fuels/oils. An oil interceptor and/or sediment trap may be required if discharge to sea is planned. Ensure permission is sought from the SCE first.

[31] These standards originate from the BSIE.

- Where drainage is to tie into existing municipal drainage systems, ensure compliance with the SEOMD.
- Maintain a dedicated area for concrete washing out areas. These should be on an impermeable base with a collecting system whereby water can be either transported offsite to an approved facility or disposed of to municipal sewers (with prior approval and via a testing protocol). Washout water may require pH adjusting prior to any discharge.
- Ensure wash water from any concrete casting works do not percolate or are drained to the channel.

9.7.1.4 Spills of Fuels and Oils

- Fuel stores to be kept away from the water's edge and stored appropriately (i.e. quantities of more than 200 litres should be stored on an impermeable base within a bund capable of holding 110% of the stored amount).
- Do not wash tools/plant/equipment in the waters of the channel.
- Ensure all equipment is well maintained and free from oil/fuel leaks, which could enter marine waters.
- Ensure vessel operators have in place the necessary spill response plans and equipment and that staff are trained in its use.

9.7.2 Mitigation and Monitoring during Operation

9.7.2.1 Mitigation

During operation, mitigation is largely specific to equipment and plant, which feed the outfalls and ensuring that they are maintained and operated according to design specifications.

9.7.2.2 Monitoring

Bapco (2011) provides information on the receiving waters/sediments/ecology adjacent to the two outfalls; however, the frequency of this work (i.e. every 5-years) is low. It is advised that in order to assess the quality of effluent, and its potential impacts upon marine water quality, an effective monitoring programme be developed; the following should be considered:

- Establish monitoring points for each point of discharge to the main and #6OWS channels; this will enable better control and understanding should effluents to sea show unexpected elevated levels of contaminants;
- Establish a monitoring protocol for defined parameters, which facilitates the regular monitoring of effluents discharged to sea. An online system should be considered to enable constant data streams, which can then be linked to additional monitoring strategies (e.g. monitoring of marine waters and ecology).

The client may wish to consider remedial action for recirculation of temperatures at the Bapco intake based on the results of the modelling.

9.8 Summary

Tables 9.21. and **9.22** provide a summary of the environmental impacts and mitigation requirements for construction and operational phases respectively.

9.9 References

Bapco (2011) Marine Environment Assessment.

CCME (2014) Canadian Environmental Quality Guidelines: Canadian Water Quality Guidelines for the Protection of Aquatic Life: Summary Table (Online). http://st-ts.ccme.ca/ (Viewed May 2016).

Deltares (2008) Land Reclamation Manual. Ministry of Works, Kingdom of Bahrain

DERM (2009) *Queensland Water Quality Guidelines,* Department of Environment and Resource Management, Australia.

Dubai Municipality, (2003). Marine Water Quality Objectives.

EACS (May 2016) Bapco Modernization Program Environmental and Social Impact Assessment (ESIA) Marine Environmental Baseline Survey (MEBS) Report. (**Appendix 9A**).

HR Wallingford (May 2016) Bapco Modernization Program Thermal dispersion model. DEM7669-RT001-R02-00. (**Appendix 9B**).

Kingdom of Bahrain EIA-8 (2010) Guidelines on Key Environmental Mitigation Measures Pertaining to Reclamation Methodologies of Large-Scale Projects.

Kingdom of Bahrain EIA-9 (2010) Guidelines on TSS monitoring Programme of Large Scale Projects Involving Intensive Dredging and Reclamation Operations.

Kingdom of Bahrain Ministerial Order No. 3 of 2001 – Amendments to Tables in Ministerial Order No. 10 of 1999 with Respect to Environmental Standards (Air and Water) and its Amendments in Ministerial Order No. 2 of 2001.

Presidency of Meteorology and Environment (2012) *The Kingdom of Saudi Arabia's (KSA) Environmental Quality Objectives (EQOs) for Ambient Marine Water Quality.*

UK Environment Agency – Environmental Quality Standards (EQS) − based upon substances detailed in the European Union's Dangerous Substances Directive (76/464/EEC and Daughter Directives).

USEPA (2014) National Recommended Water Quality Criteria. United States Environmental Protection Agency.

Table 9.23 Summary of Hydrodynamics and Water Quality

Impact	AOI	Significance	Mitigation/Enhancement Measures	Residual Impact
Construction Phase				
Discharge of Sewage Effluent from Labour Camps	AOI 1	To be determined	To be considered further during EPC Phase	To be determined
Terrestrial Dewatering – Introduction of fines and Contaminants to Sewater	AOI 1	Minor Adverse		Negligible/ Minor Adverse
	AOI 2			Negligible/ Minor Adverse
Surface Water Run-off	AOI 1	Minor Adverse		Negligible/ Minor Adverse
	AOI 2	Minor Adverse		Negligible/ Minor Adverse
Spillages of Fuels, Chemicals and Wastes	AOI 2	Negligible		Negligible
	AOI 3	Minor Adverse		Minor Adverse
Impact on Construction Operations on Existing Seawater Intakes	AOI 3	To be determined	To be considered further during EPC Phase	To be determined
Operational Phase				
Impact of Routine Operation of BMP Post-BMP on Water Quality	AOI 1	Negligible		Negligible
Impact of Operational Regime on Plume Dispersion	AOI 1			Not possible to assign an impact.
Impact of Bahrain 2030 NPDS Layout on the Operational Regime (extent of plume and recirculation temperatures	AOI 1	Minor Adverse		Not possible to assign an impact.
Impact of Operational Discharge on Seawater Intakes	AOI 1	Negligible		Negligible

10 SEDIMENT QUALITY

10.1 Introduction

Marine sediment serves as an important habitat for ecological receptors and any changes in its physical, chemical or biological characteristics can have significant impacts. This section addresses potential impacts arising from the construction and operation of the BMP upon the three AOI.

An understanding of existing marine sediment quality across the AOI can provide a useful indication of the extent of environmental contamination and the potential for the resuspension of sediment-associated contaminants during construction activities. It also provides a baseline from which to compare any changes in the potential environmental loading as a result of the operation of the BMP.

10.2 Legislation and Guidance

The Kingdom of Bahrain has not developed its own marine sediment quality guidelines and so a number of international guidelines have been referred to during the assessment. Caution must be adopted when using international guidance as there will be differences in guidance depending on local conditions, and not will be relevant to the Kingdom of Bahrain. For the purposes of the present study, the following guidelines have been referred to; full details are provided in the stand-alone Marine Environmental Baseline Survey (MEBS) Report, appended to this ESIA Report (**Appendix 9B**).

- Australian Government National Assessment Guidelines for Dredging (NAGD) (Commonwealth of Australia, 2009) and ANZECC/ARMCANZ 2000 for substances not listed in the aforementioned document (as recommended). The Screening Level (or 'ISQG Trigger Value') is a threshold concentration below which the frequency of adverse biological effects is expected to be very low. Exceeding the screening level does not necessarily mean that adverse biological effects will occur in the sediments, but that further investigations should be carried out to confirm this.
- The Interim Marine Sediment Quality Guidelines (ISQGs) issued by CCME (Canadian Council of Ministers of the Environment, 2007). The Canadian ISQGs include Threshold Effect Levels (TELs) and Probable Effect Levels (PELs). The TEL is the threshold value below which concentrations of sediment-associated chemicals are unlikely to represent a significant hazard to aquatic organisms. The PEL represents the lower limit of the range of chemical concentrations that are almost always associated with adverse biological effects (CCME, 1995).
- The UK Centre for Environment, Fisheries and Aquaculture Science (CEFAS) guideline 'action levels' for the disposal of dredged material at sea (DEFRA, 2012). If concentrations are between CEFAS Action Level 1 and 2 then assessment is required. If concentrations exceed Level 2 then the sediment may not be acceptable for disposal at sea.
- Dutch Target and Intervention Values, 2000. Target Values (TV) indicate the level at which there is a sustainable soil quality and which are deemed acceptable for human and animal life. Intervention Values (IV) indicate when functional properties of the soil for human plant and animal life is seriously impaired threatened and which excessive levels of contamination is present.

- Swedish Environmental Protection Agency (EPA) Environmental Quality Criteria (EQC) for seabed sediments as referenced in Bapco, 2011[32]. Concentrations less than the standards are considered 'safe', while concentrations between these and less than a factor of 3 higher are considered 'moderately serious', a factor 3 to 10 times higher 'serious' and >10 'very serious' (Bapco, 2011).

10.3 Assessment Methodology

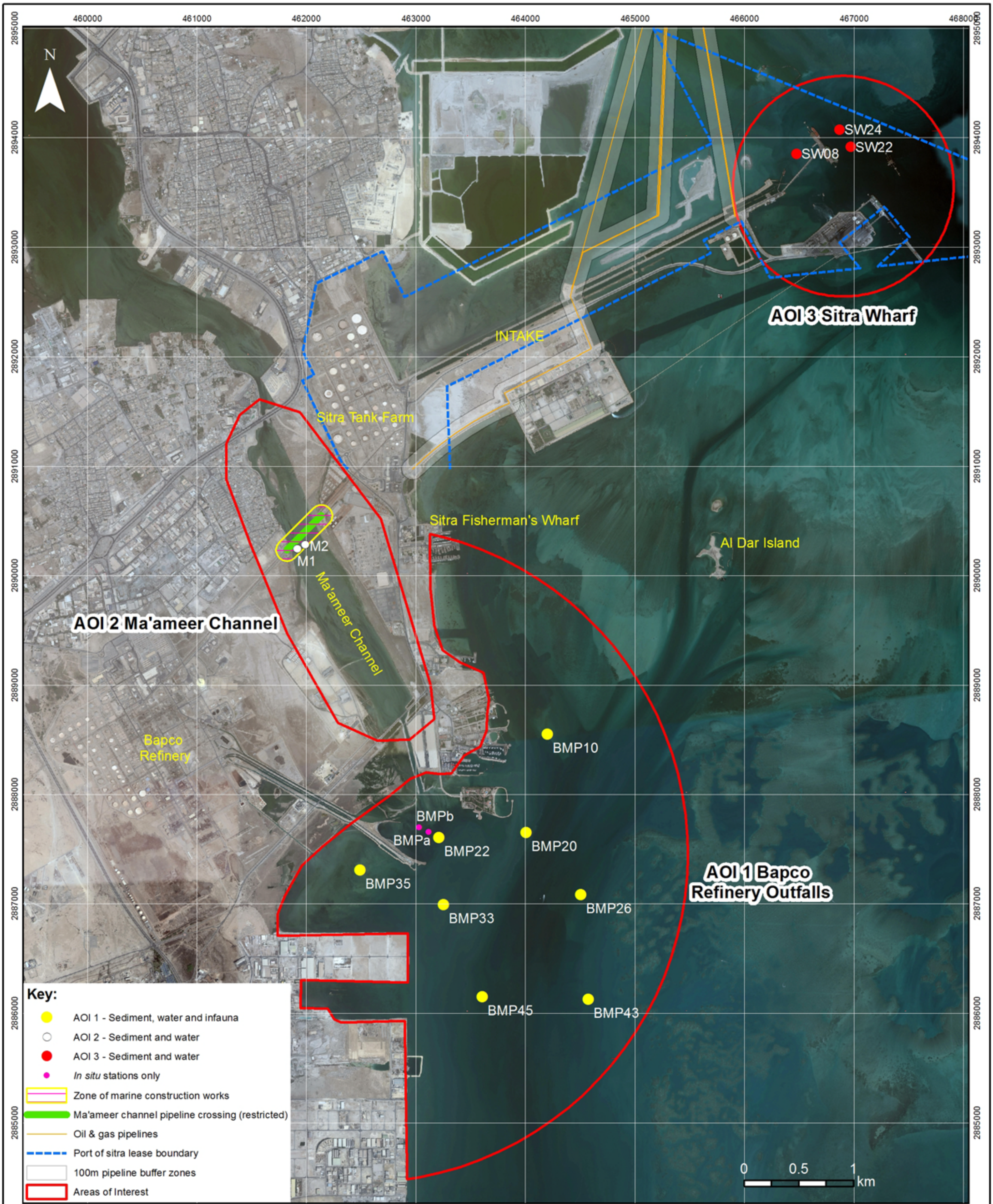
The assessment of impacts on sediment quality was approached by first defining the quality of sediments within the three marine AOI. This was achieved by reviewing existing data sets (Bapco, 2011) and conducting primary surveys. Subsequently, significance criteria were developed from which a quantitative assessment could be made of potential impacts.

10.3.1 Marine Baseline Survey

Assessment of marine sediment quality required the field-based collection of samples from eight locations within AOI 1, two locations within AOI 2 and three locations within AOI 3 (see **Figure 10.1**). Samples were collected using a 0.05 m^2 Van-veen grab[33], and stored in pre-prepared sample containers provided by the testing laboratory (ALS Arabia) and subsequently processed according to strict protocols.

All analytical procedures were developed from established internationally recognized procedures such as those published by the United States Environmental Protection Agency (US EPA), American Public Health Association (APHA) and National Environment Protection Measures (NEPM). The reader is directed to the stand-alone MEBS Report.

[32] Swedish standards have been referred to as they were used in Bapco, 2011.
[33] Sediment samples from AOI 2 were collected by hand due to extremely shallow water depths.



Title: **Location of Infauna, Sediment Sampling and Water sampling Locations (AOI 1, 2 & 3)**		Client: Bapco Technip
Project: Bapco Modernization Program		
Date: June 2016	Figure No.: 10.1	Consultant: Environment Arabia
Datum: WGS 84 - UTM 39N	Scale: 1:45,000 (A4)	

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10.3.2 Assessment Criteria and Methodology

Our methodology of quantifying impacts is based on the product of the sensitivity of the receptor (**Table 10.1**), and the magnitude of the impact.

With respect to marine sediments, **Table 10.1** provides a scale of environmental receptor sensitivity that has been used in the assessment process.

Table 10.1 Receptor Sensitivity Criteria

Receptor Sensitivity	Description
High	Marine sediments are uncontaminated and considered to be undisturbed by anthropogenic activities - they are in a natural state.
Medium	Marine sediments show no sign of elevated levels of contaminants. Signs of physical disturbance by past activities are noticeable (e.g. limited deposition of surface materials); however, the sediments remain largely undisturbed.
Low	Sediments exhibit contamination at levels which may hinder marine biodiversity. Sediments show signs of physical disturbance (e.g. following dredging) and bear little resemblance to that previously present.
Negligible	Sediments are considered severely contaminated and/or exhibit significant change resulting from past and ongoing activities (e.g. maintenance dredging).

Quantifying the magnitude of an impact is defined via a number of sub-criteria. Typically these may be informed following specialist modelling studies (e.g. sediment dispersion modelling studies), expert opinion, review of contractor's methodologies, and reference to published data (e.g. sediment quality guidelines). Criteria include:

- **Extent:** whether the impact would occur onsite, in a limited (Li) area (within 1 km of the site); local (Lo) area (within, say, 5 km of the site or within the relevant Municipality); nationally (na) or internationally (in).
- **Duration:** whether the impact would be temporary (T-less than one year), short-term (ST-one to five years), medium term (MT-five to ten 10 years), long-term (LT-over ten years), or permanent (P).
- **Likelihood:** based on the best available information (primary and secondary data), the likelihood of an impact is assigned a classification based upon the probability of an event occurring (i.e. unlikely (U), likely (Li), and definite (De)).
- **Magnitude:** the quantifiable effects of impacts, measured where appropriate against an appropriate environmental standard (national, regional or international) or based on expert judgment.
- **Direct** (D): impacts that result from direct interaction between a project activity and the receiving environment (e.g. destruction of habitat beneath development footprint).
- **Indirect** (I): impacts that result from other activities as a consequence of the project (e.g. smothering of species at a nearby location as a result of deposition of suspended sediment generated by construction activity).

To calculate the level of significance, the formula presented below has been utilized.

Impact Significance = Magnitude of Impact x Sensitivity of Receptor

Table 10.2 provides classifications of the resulting impact significance and these are described further in **Table 10.3.**

Table 10.2 Calculation of Impact Significance

MAGNITUDE	**High**	Minor/Moderate	Moderate	Moderate/Major	Major
	Medium	Minor	Minor/Moderate	Moderate	Moderate/Major
	Low	Negligible/Minor	Minor	Minor/Moderate	Moderate
	Negligible	Negligible	Negligible	Negligible/Minor	Minor/Moderate
		Negligible	**Low**	**Medium**	**High**
		VALUE AND SENSITIVITY			

Table 10.3 Significance of impact

Impact significance	Impact Description
Negligible	Impact is virtually imperceptible over baseline
Minor Adverse	Impacts are of low intensity with short term duration. The potential for recovery to existing conditions is good with return to baseline conditions over a short period of time
Moderate Adverse	Activities are likely to result in significant physical/chemical/biological impacts in the medium term and from which the potential for partial recovery exists.
Major Adverse	Activities will result in significant change to existing physical, chemical or biological conditions of marine sediments. This may arise due to construction works (e.g. dredging), changes in natural sediment transport regimes, or contamination via anthropogenic activities. The potential for a return to baseline conditions is extremely low; impacts are considered long term and/or permanent.

10.4 Baseline Marine Sediment Quality

10.4.1 Summary of Previous Survey (Bapco, 2011)

The previous marine survey undertaken in 2011 provides data from 30 years of survey within AOI 1, which shows a clear trend of decreasing contamination for hydrocarbons, polyaromatic hydrocarbons (PAHs) and metals; **Table 10.4** presents data sets for two example sites.

Table 10.4 Summary of Bapco (2011) Data Sets

Station	Parameter	Year (value)	Year (value)
B6	Petroleum Hydrocarbons	1981 (8800 mg/kg)	2011 (192 mg/kg)
B13	Poly Aromatic Hydrocarbons	1992 (1.26 mg/kg)	2011 (0.83 mg/kg)
B6	Lead	1992 (1010 mg/kg)	2011 (42.3 mg/kg)
	Cadmium	1992 (0.31 mg/kg)	2011 (0.103 mg/kg)
	Mercury	1992 (0.69 mg/kg)	2011 (0.144 mg/kg)

10.4.2 Summary of Parameters from EACS Sediment Survey

The following provides a brief summary of the suite of parameters that were tested during the MEBS.

- Metals are elemental pollutants that are not subject to degradation and so are essentially permanent additions to the marine environment.
- PAHs are non-polar, lipophylic and persistent compounds in the marine environment and as such are of particular toxicological and environmental concern. PAHs are generally considered to be toxic to marine organisms due to their mutagenic and carcinogenic effects.
- Total Petroleum Hydrocarbons (TPHs) can be highly toxic to marine organisms at very low concentrations. In addition to direct lethal effects, petroleum hydrocarbons can exert sub-lethal effects, including reduced growth, altered feeding behaviour, and lower reproductive success (GESAMP, 1993).
- Organotin compounds are chemical compounds based on tin with hydrocarbon substituents and are typically classified according to their oxidation states. They are toxic endocrine-disruptor chemicals which bioaccumulate and, even at very low levels, they may severely impact the health and development of marine organisms.
- Nutrients such as nitrate are essential plant and algal nutrients. High levels in coastal waters may stimulate the growth of large quantities of marine plants and algae. When the plants and algae die, they are decomposed by aerobic bacteria, which utilise dissolved oxygen. This process is called ‘eutrophication’ and may result in a decrease in dissolved oxygen levels, leading to the death of aerobic organisms including fish and shellfish.

The results of the sediment survey are presented in **Table 10.5**.

10.4.3 Summary of Marine Sediment Quality within AOI 1 (EACS Survey)

Within AOI 1, the sediment quality is, for most parameters tested for, considered uncontaminated when compared to project referenced guidance.

Recorded levels of PAHs were less than 0.5 mg/kg indicating that this form of pollution was not detected in any of the samples. None of the TPH fractions (Gasoline Range Organics (GRO), Diesel Range Hydrocarbons (DRH) or the ‘heavy’ fraction were detected in any of the sediment samples collected. Organotin values were not elevated at any of the stations sampled (all values recorded as <1.0 µg/kg and thus not in breach of any of the guideline values[34].

Breaches were only identified at station BMP 22 (**Figure 10.1**) for the following parameters.

- Copper (value recorded - 87.0 mg/kg): the Australian NAGD ISQG (65.0 mg/kg), Canadian Threshold Effects Level (TEL) (18.7 mg/kg for copper), CEFAS Action Level (AL) 1 (30.0 mg/kg), Dutch Threshold Value (TV) (36.0 mg/kg) and Swedish Environment Quality Criteria (EQC) (80.0 mg/kg) for copper.
- Lead ranged from 'not detected' at 5 of 8 of the locations sampled (< 5.0 mg/kg) to a maximum of 89.00 mg/kg at BMP 22. The aforementioned result breaches the Australian NAGD ISQG (50.0 mg/kg), the Canadian PEL (30.2 mg/kg), CEFAS AL 1 (50.0 mg/kg), and Dutch IV (85.0 mg/kg). However, BMP 22 recorded a value for lead that was lower than the Canadian PEL, CEFAS AL 2, Dutch IV and Swedish EPA EQC.
- The values recorded for zinc ranged from 6.0 mg/kg (BMP 26) to 171 mg/kg at BMP 22. BMP 22 breached the Canadian TEL (124 mg/kg) but was under all of the remaining guideline values reported (Australian NAGD ISQG, Canadian PEL, CEFAS AL 1 and AL 2, Dutch TV and IV, and Swedish EPA EQC).

The results of the Particle Size Analysis (PSA) indicated that the majority of the survey locations were described as either 'gravelly sand' or 'slightly gravelly sand' with a relatively low silt content (<12 %). Silt content ranged from 2% at station BMP 20 (in the middle of the channel) to 88% at BMP 22 closest to the Refinery main outfall. The second siltiest station was BMP 33 situated in the vicinity of the Refinery intake (32 % silt).

10.4.4 Summary of Marine Sediment Quality within AOI 2 (EACS Survey)

Within AOI 2, two sediment samples were taken within the footprint of the proposed construction works. The MEBS in this area is, therefore, not representative of the entire Ma'ameer Channel.

For most parameters tested the sediment quality results were considered uncontaminated. Both samples recorded levels for all 16 PAHs as <0.5 mg/kg and the sum of the PAHs was also <0.5 mg/kg indicating that this form of pollution was not detected. None of the TPH fractions (GRO, DRH or the 'heavy' fraction) were detected at either of the stations.

There were some breaches in the guideline values as follows:

- The copper value (26 mg/kg) recorded at M1 breaches the stringent Canadian TEL (set at 18.7 mg/kg); however, it is in line with all of the other guideline values for this parameter.
- The CEFAS AL 2 was breached for the parameters MBT (2.55 mg/kg) and TBT (1.92 mg/kg) in the sample collected from station M2. The NAGD was breached at

[34] Guideline values exist for DBT, MBT and TBT (CEFAS AL 1 is set at 0.1 mg/kg and CEFAS AL 2 is set at 1.0 mg/kg). It is not, however, possible to make any inference as to whether or not the samples are compliant with the more stringent CEFAS AL 1 due to the limitations of the detection limits of the laboratory. The NAGD ISQG is set at 1µgSn/kg (0.001 mg/kg) for all organotin compounds.

both M1 and M2 for all parameters, with the exception of those which were recorded at <1 mg/kg; the detection limit is higher than the NAGD standard.

Both M1 and M2 contained 5 % gravel. M1 (closer to the western shoreline of the channel) contained a significantly higher silt content (66 %) than station M2 situated closer to the centre of the channel (23 %). M1 is classified as 'slightly gravelly mud' whilst M2 is classified as 'slightly gravelly muddy sand'.

10.4.5 Summary of Marine Sediment Quality within AOI 3 (EACS Survey)

Within AOI 3, for most parameters tested the sediment quality results are considered uncontaminated. None of the TPH fractions (GRO, DRH or the 'heavy' fraction) were detected within samples.

Breaches were, however, recorded as follows:

- The copper values recorded ranged from 26 mg/kg (SW 24) to 35 mg/kg (SW 22). These values are all in breach of the stringent Canadian TEL, which is set at 18 mg/kg. In addition, the values recorded at SW 08 and SW 22 were equal to or breached the CEFAS AL 1 (30 mg/kg). However, the values recorded were all in line with the remaining guideline values referenced in this document.
- The sum of PAH was 1.8 mg/kg for SW 22. This value is above the Dutch TV (set at 1.0 mg/kg), but is in line with the Dutch IV and Australian NAGD ISQG trigger value.
- The values for DBT, MBT and TBT at all 3 stations sampled breached the Australian NAGD ISQG value of 1.0 µg/kg, and the CEFAS AL 1 (0.1 mg/kg) and CEFAS AL 2 (1.0 mg/kg). In addition, the values recorded for DOT and MOT breached the Australian NAGD ISQG at all 3 stations and the Australian NAGD ISQG was breached at SW 08 for the parameters TeBT and TPhT.

It is unsurprising that the results for organotins are elevated in AOI 3 in comparison to AOI 1 and AOI 2 due to the large numbers of ships which regularly dock in the area. In 2003, the International Maritime Organisation (IMO) banned the use of tributyltin as a biocide in anti-fouling paint; however, they are common contaminants in ports and harbours - (Australian Government National Measurement Institute, 2016).

All 3 samples collected within AOI 3 were very similar with regard to composition, with each recording 1 % gravel, sand content ranged from 50 – 55 % and silt content ranged from 44 – 49 %. Each sample was classified as 'sandy mud'.

Table 10.5 Summary of Sediment Quality Results (AOI 1, 2 & 3)[35]

Parameter	LOR	Unit	Station and AOI												
			AOI 1								AOI 2		AOI 3		
			BMP 10	BMP 20	BMP 22	BMP 26	BMP 33	BMP 35	BMP 43	BMP 45	M 01	M 02	SW 08	SW 22	SW 24
Arsenic	5	mg/kg	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Cadmium	1	mg/kg	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Chromium	2	mg/kg	6.0	5.0	30.0	<2.0	8.0	5.0	4.0	3.0	19.0	14.0	11.0	14.0	11.0
Cobalt	2	mg/kg	<2.0	<2.0	2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Copper	5	mg/kg	<5.0	<5.0	87.0	<5.0	13.0	<5.0	<5.0	<5.0	26.0	13.0	30.0	35.0	26.0
Lead	5	mg/kg	<5.0	<5.0	89.0	<5.0	13.0	26.0	<5.0	<5.0	9.0	7.0	5.0	8.0	6.0
Mercury	0.1	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Nickel	2	mg/kg	<2.0	3.0	28.0	<2.0	6.0	3.0	3.0	3.0	18.0	9.0	12.0	15.0	11.0
Strontium	2	mg/kg	5,720.0	5,250.0	2,120.0	3,880.0	3,810.0	7,050.0	4,030.0	3,120.0	2,120	5,780	3,300.0	3,370.0	3,060.0
Vanadium	5	mg/kg	<5.0	<5.0	28.0	<5.0	8.0	<5.0	5.0	<5.0	17.0	11.0	15.0	16.0	12.0
Zinc	5	mg/kg	9.0	10.0	171.0	6.0	22.0	12.0	10.0	10.0	87.0	41.0	45.0	51.0	38.0
Sum of Polycyclic Aromatic Hydrocarbons	0.5	mg/kg	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	1.8	<0.5	<0.5
Sum of C10-C40 Fraction	50	mg/kg	<50.0	<50.0	<50.0	<50.0	<50.0	<50.0	<50.0	<50.0	<50.0	<50.0	<50.0	<50.0	<50.0
Dibutyltin (DBT)	1.0	µg/kg	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	4.65	7.51	8.35
Dioctyltin (DOT)	1.0	µg/kg	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	7.71	8.26	3.95	1.69	20.6
Diphenyltin (DPhT)	1.0	µg/kg	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Monobutyltin (MBT)	1.0	µg/kg	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	2.55	7.13	9.38	12.9
Monooctyltin (MOT)	1.0	µg/kg	<1.0	<1.0	1.87	<1.0	1.53	<1.0	<1.0	<1.0	13.6	18.7	8.66	3.77	4.01

[35] Results highlighted in red indicate a breach of one or more of the guidance highlighted in **Section 10.2**. Results in green indicate compliance. Results with no highlight indicate that no guideline has been identified for the parameter.

Parameter	LOR	Unit	Station and AOI												
			AOI 1								AOI 2		AOI 3		
			BMP 10	BMP 20	BMP 22	BMP 26	BMP 33	BMP 35	BMP 43	BMP 45	M 01	M 02	SW 08	SW 22	SW 24
Monophenyltin (MPhT)	1.0	µg/kg	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Tetrabutyltin (TeBT)	1.0	µg/kg	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	11.1	<1.0	<1.0
Tributyltin (TBT)	1.0	µg/kg	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	1.92	73.2	17.2	11.5
Tricyclohexyltin (TCyT)	1.0	µg/kg	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Triphenyltin (TPhT)	1.0	µg/kg	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	2.40	<1.0	<1.0

10.5 Impact Assessment

10.5.1 Assignment of Sensitivity

When taking into account the criteria highlighted in **Table 10.1**, the following sensitivity of the marine sediments has been assigned to each of the three AOI:

AOI 1 - The marine sediment quality in AOI 1 close to the Bapco outfalls, has been subject to historical contamination which, according to Bapco 2011 marine survey report, has progressively improved over the last 30 years. A degree of anthropogenic disturbance not connected with the Refinery is also evident, associated with the dredging of a marine navigational channel, and coastal reclamation both north and south of the Bapco outfall locations (e.g. Ras Zuwayed).

The results of the EACS marine baseline survey (see **Table 10.5**) indicate that the sediments are largely uncontaminated, with the exception of BMP 22, which is located close to main outfall. As such, despite the sediments being historically disturbed, recoverability is evident and the overall sensitivity is assigned as 'medium'.

AOI 2 - The baseline study indicates that the sediments in the vicinity of the proposed pipeline bridge in Ma'ameer Channel, are largely uncontaminated. However, organotins were encountered and so it is recommended that additional sampling is conducted to confirm the accuracy of the results obtained.

A significant amount of reclamation has been undertaken at both the northern and southern ends of the Ma'ameer Channel which has led to restrictions in water flow. To EACSs knowledge, it has never been dredged. EACS is unaware of any direct pollutant sources into the Ma'ameer Channel; however, it is possible that pollution may enter from Tubli Bay to the North. Based on the aforementioned information, the sensitivity of the AOI 2 is assigned as medium.

AOI 3 - The EACS baseline survey indicates that the sediments do exhibit some level of contamination particularly with organotins, PAH's and copper. The area is, however, highly disturbed from historical dredging and is situated within an industrial area; therefore, the sensitivity is considered to be low.

10.5.2 Impacts during Construction

A summary of the predicted impacts for the construction phase is provided in **Table 10.6**.

AOI 1 - there are no planned construction activities required for the BMP in AOI 1. This AOI is not considered further in this section.

AOI 2 – Within the Ma'ameer Channel a new pipe bridge will be constructed and the existing one decommissioned. The methodology for construction is not available at the time of writing, but it is likely that construction will involve temporary reclamation in order to facilitate construction works. The source of fill material is yet to be determined, but it is likely to be trucked to site.

AOI 3 – Marine construction activities for the BMP have been described in **Section 2** and are derived from COWI (2016). In brief, new sealines within AOI 3 will be towed offshore and laid on the seabed (no trenching activities are anticipated). The pipeline will then be covered with pre-cast mattresses and subsequently rock[36].

10.5.2.1 Marine Sediment Loading

AOI 2 - Decommissioning, piling, reclamation, and removal of material (removal of temporary reclamation) activities have the potential to result in the resuspension and deposition of material (predominately fines - <63 µm) within adjacent areas. Given the scope of works, affected areas are expected to be limited to approximately 100 m north and south of works although this estimate is, in the absence of dispersion modelling, qualitative. There is a potential for the spread of contaminants, hence, mitigation is presented in **Section 10.6**.

Reclamation works (if undertaken[37]) are considered small relative to other coastal developments in Bahrain; however, these activities would present the greatest source of sediment loading related to this project.

Based on the sensitivity of the receptor (medium) and magnitude of the impact (low) the impact significance is described as minor adverse. This is based on the current level of detail regarding the construction methodology.

AOI 3 - During the pipeline construction, impacts upon sediment quality will be limited to the disturbance of marine sediment beneath the footprint of the pipelines and protective layers (i.e. concrete mattresses and rock). The construction works are expected to be limited in duration and geographical extent, with limited resuspension and deposition of sediments; an impact of minor adverse is therefore assigned.

10.5.2.2 Spread of Contamination

AOI 2 - The potential for the resuspension and deposition of contaminated material to adjacent areas is considered to be low. Based on the sensitivity of the area, a minor adverse impact has been assigned.

AOI 3 - The potential for the resuspension and deposition of contaminated material to adjacent areas is considered to be low. Based on the sensitivity of the area, a minor adverse impact has been assigned.

10.5.3 Impacts During Operation

A summary of the predicted impacts for the operation phase of the BMP are presented in **Table 10.7**.

AOI 1 – Bapco (2011) indicates that the sediment quality in Farisiyah Bay has improved over the last three decades (see **Appendix 9B**). This is likely to be as a result of

[36] It is assumed that no backfilling or trenching works will be conducted as part of the methodology due to the presence of sensitive receptors in the area (existing pipelines). This methodology has not been assessed as part of the ESIA.

[37] The methodology for the creation of the new pipeline bridge crossing has not been finalised at the time of writing. A separate SCE screening form was submitted for these works.

improvements to the quality of effluent discharged from the Refinery. The BMP is not expected to significantly alter the quality or volume of effluent discharged, and hence sediment quality is unlikely to be impacted by the BMP.

AOI 2 – Routine operation, post BMP, will have no impact on marine sediments within the Ma'ameer Channel, as there are no sources of input into the marine environment from planned operations.

AOI 3 - Routine operation post BMP will have no impact on marine sediments within the Sitra Wharf area, as there are no sources of input into the marine environment from planned operations.

Table 10.6 Impact Summary Table – Marine Construction Activities

Description of Impact	AOI	Receptor sensitivity	Magnitude	Features of impact				Impact Significance	Residual Impact (following mitigation)
				Extent	Duration	Likelihood	Type of impact		
Marine Sediment Loading	AOI 1	M	-	-	-	-	-	No Impact	No Impact
	AOI 2	M	M	Lo	T	Li	D	Minor	Negligible
	AOI 3	L	L	Lo	T	Li	D	Minor	Negligible
Spread of Contamination	AOI 1	M	-	-	-	-	-	No Impact	No Impact
	AOI 2	M	L	Lo	T	Li	D	Minor	Negligible
	AOI 3	L	L	Lo	T	U	D	Minor	Negligible

LT – Long Term, L-Low, H-high, N-negligible, Lo-local, T – temporary, M-medium, De-definite, U-unlikely, D-direct, I-indirect. Li-likely "-" – No values assigned / does not occur

Table 10.7 Impact Summary Table – Routine Operation Post BMP

Description of Impact	AOI	Receptor sensitivity		Features of impact				Impact Significance	Residual Impact (following mitigation)
			Magnitude	Extent	Duration	Likelihood	Type of impact		
Changes to Quality of Effluent	AOI 1	M	N	Lo	LT	D	I	No Impact	No Impact
	AOI 2	M	-	-	-	-	-	No Impact	No Impact
	AOI 3	L	-	-	-	-	-	No Impact	No Impact

10.6 Mitigation

10.6.1 Construction

It is recommended that prior to commencement of works, additional sediment samples are taken within AOI 2 and analysed for organotins. Should elevated levels be detected, then a contaminated remediation plan and/or additional mitigation (i.e. removal of contaminated sediments) should be implemented.

The deposition of fine material generated by the proposed marine construction activities is expected to be small and unlikely to significantly alter the existing physical, chemical or biological properties of the neighbouring seabed in either AOI 2 or AOI 3. However, the following measures should be considered:

- The contractor and appointed environment consultant is to liaise with ALBA to further quantify the risks and confirm the necessary mitigation which needs to be put in place. This will require establishing TSS thresholds for the ALBA intake, development of a monitoring protocol and consideration of additional physical mitigation (i.e. installation of silt curtains around the intake).
- Excavated material from piling operations within Ma'ameer Channel is not to be dumped back to the Channel but is to be disposed of appropriately on land.
- When reclaiming in AOI 2 (this is actually a temporary work platform[38]), use only clean material with less than 10% fines and as defined in Deltares (2008) Land Reclamation Manual. Ministry of Works, Kingdom of Bahrain, and EIA-8 Guidelines on Key Environmental Mitigation Measures Pertaining to Reclamation Methodologies of Large-Scale Projects.
- SCE (2010) EIA-9 Guidelines on TSS Monitoring Programme of Large Scale Projects Involving Intensive Dredging and Reclamation Operations include relevant water quality standards for reclamation activities. These should be taken into consideration for any reclamation works. Given the relatively small scale of works, the requirement to undertake TSS monitoring is questionable, however, it is recommended that monitoring occurs to confirm the effectiveness of mitigation.
- Attempt to avoid trenching works; if this is unavoidable select methods that result in the least disturbance of seabed sediments (e.g. closed clam shell buckets) and ensure that excavated material is not dumped to sea.
- Should covering of trenches be required, use suitable material with low fine content. Adhere to Deltares (2008) Land Reclamation Manual. Ministry of Works.
- Should trenching/backfilling take place, develop a TSS monitoring protocol, which addresses the thresholds of sensitive receptors (e.g. ALBA intake). Ensure monitoring is conducted as per the agreed protocol and ameliorate actions are in place prior to commencement should a breach occur.

10.6.2 Operation

No site-specific mitigation is recommended; however, the development of a detailed in-house monitoring programme addressing the quality of effluent from the Bapco outfalls is essential in order to confirm compliance with design specifications and compliance with the Bahrain Industrial Effluent Standards (highlighted in **Table 9.5** and **9.6** in **Section 9**).

[38] Details of which have not been determined.

The acquisition of site-specific baseline data provides a platform upon which ongoing and future monitoring programmes can be based.

10.7 Monitoring

10.7.1 Construction

Adherence to the mitigation measures should be checked as part of the regular environmental audit for the construction phase.

10.7.2 Operation

It is recommended that the long term monitoring of marine sediments associated with AOI 1 be continued and, possibly amended to allow for more frequent monitoring campaigns.

10.8 Summary

Table 10.8 presents a summary for the parameter of marine sediment quality.

10.9 References

(ANZECC/ARMCANZ, 2000) *Australian and New Zealand Guidelines for Fresh and Marine Water Quality.* Australian and New Zealand Environment and Conservation Council/Agriculture and Resource Management Council of Australian and New Zealand, Canberra, Australia, 2000.

(Australian Government National Measurement Institute, 2016) Organotins in the Marine Environment. Viewed online May 2016: http://www.measurement.gov.au/SERVICES/ENVIRONMENTALTESTING/Pages/OrganotinintheMarineEnvironment.aspx

(Bapco, 2011) Marine Environment Assessment, Bapco, 2011

(CCME, 2007) Canadian sediment quality guidelines for the protection of aquatic life: Summary tables. In: Canadian Environmental Quality Guidelines, 2007, Canadian Council of Ministers of the Environment, Winnipeg, Canada.

(Commonwealth of Australia, 2009) The National Assessment Guidelines for Dredging. Commonwealth of Australia, Canberra, Australia. 81 pp.

(DEFRA, 2012) CEFAS: Use of Action Levels in Dredged Material Assessments.

(Dutch Target and Intervention Values, 2000) “the New Dutch List” accessed online May 2016:http://www.esdat.net/Environmental%20Standards/Dutch/annexS_I2000Dutch%20Environmental%20Standards.pdf.

Table 10.8 Summary of Marine Sediment Quality

Impact	AOI	Nature of Impact	Significance	Mitigation/Enhancement Measures	Residual Impact
Construction Phase					
Marine Sediment Loading	AOI 1	-	No impact	None required.	No impact
	AOI 2	Temporary	Minor adverse	• Fully contain the work corridor using silt curtains or containment bunds as appropriate. • Use suitable material for any temporary reclamation as defined Deltares Land Reclamation Manual and EIA-8.	Negligible
	AOI 3	Temporary	Minor adverse	• See **Section 9.8.1.2**	Negligible
Spread of Contamination	AOI 1		No impact	None required.	No impact
	AOI 2	Temporary	Minor	• Prior to commencement of construction, additional sediment samples should be taken and analysed for organotins. Should elevated levels be detected, a contaminated remediation plan and/or additional mitigation should be implemented.	Negligible
	AOI 3	Temporary	Minor	• See **Section 9.8.1.2**	Negligible
Operation Phase					
Changes to Quality of Effluent	AOI 1	Long Term	No impact	None required.	No impact
	AOI 2	Long Term	No impact	None required.	No impact
	AOI 3	Long Term	No impact	None required.	No impact

11 MARINE ECOLOGY

11.1 Introduction

The potential impacts of the BMP upon marine and coastal ecological interests[39] have been assessed based upon the sensitivity of habitats and their associated biotic communities, and the quantification of construction and operational impacts. An understanding of the biology of effected receptors is essential, supported by collation of secondary data, primary surveys, and published articles (e.g. identified tolerances to known physical, chemical and biological impacts). It is important to note that as the BMP will not result in any significant change to the physical/chemical/biological constituents of effluents to sea, the status quo of the ecological receptors within the area of influence of existing discharges, is unlikely to be affected.

11.2 Legislation and Guidance

Bahrain is party to international and regional environmental agreements and protocols, in addition to possessing national environmental legislation, which either directly or indirectly has influence on the management and/or protection of the marine environment.

The following sections identify key agreements/legislation, which have relevance to the project. Reference is also made to **Section 9** and **10** (Hydrodynamics and Water Quality and Sediment Quality) and to specific Environmental Quality Standards (EQS), which are aimed at protecting the marine environment.

11.2.1 International

- Convention on Biological Diversity was signed by the Kingdom of Bahrain[40] on the 9th June 1992, ratified on the 30th August 1996 and came into party on the 28th November 1996.
- The United Nations Convention on the Law of the Sea of 10 December 1982. The Convention provides an overarching framework aimed at regulating marine waters. Amongst others, it allows for the protection and preservation of the marine environment; and
- Protocol Concerning the Conservation of Biological Diversity and the Establishment of Protected Areas (2002). This aims to preserve environmental systems and wildlife, especially endangered species and those that migrate through the territorial waters.

In addition to the above, the Bahrain is a contracting party[41] of The Convention on Wetlands (RAMSAR), which was adopted in the Iranian city of Ramsar in 1971 and came into force in 1975. This is an intergovernmental treaty that presents the framework for cooperation on a national and international level for the conservation and appropriate use of wetlands. Bahrain has two RAMSAR sites, *Tubli* Bay (located to the north of AOI 2) and the *Hawar* Islands.

[39] Avifaunal interests are covered in Section 12, Terrestrial Ecology.
[40] Is addressed within Legislative Decree No. 9.
[41] Bahrain ratified the agreement on the 26th February 1997 (Amiri Decree 3, 1997).

Table 11.1[42] provides a list of all of the protected areas in the Kingdom of Bahrain, and the distance of each of the areas to the AOI studied as part of the BMP. Note distances are 'as the crow flies' and many of the areas are physically separated from the AOI not only be the large geographic distances, but also by land (e.g. the Ras Mumtallah IBA is on the opposite coast of the mainland).

Table 11.1 Protected Marine Areas in Bahrain, and IBAs, and Distances to the AOI

<table>
<tr><th colspan="2" rowspan="2">Protected Areas in Bahrain</th><th colspan="3">Distance from AOI</th></tr>
<tr><th>AOI 1</th><th>AOI 2</th><th>AO 3</th></tr>
<tr><td colspan="2">Tubli Bay MPA and Ramsar site - Tubli Bay was declared as protected area by Decree No. (53) of 2006</td><td>~ 5 km</td><td>Immediately adjacent to and connected to Tubli Bay</td><td>>5 km</td></tr>
<tr><td colspan="2">Hawar Islands was declared as a protected area in 1996 and designated as a RAMSAR site in 1997</td><td>>40 km</td><td>>45 km</td><td>>45 km</td></tr>
<tr><td colspan="2">Dohat Arad (Arad Bay) is a Marine Protected Area under Ministerial Order (4) of 2003*.</td><td>>16 km</td><td>>14 km</td><td>>10 km</td></tr>
<tr><td colspan="2">Reef Bul Thamah was declared a protected area following Ministerial Decree (9) of 2007*.</td><td>>80 km</td><td>>80 km</td><td>>80 km</td></tr>
<tr><td colspan="2">Mashtan Island is Protected Area by Ministerial Order (1) of 2002*.</td><td>>30 km</td><td>>35 km</td><td>~40 km</td></tr>
<tr><th colspan="5">Important Bird Areas[43]</th></tr>
<tr><td rowspan="3">In addition Bahrain has 3 marine Important Bird Areas (IBA):</td><td>South West Coast IBA (Ras Mumtallah) [44]</td><td>~25 km</td><td>~25 km</td><td>>30 km</td></tr>
<tr><td>Hawar Islands IBA</td><td>>40 km</td><td>>45 km</td><td>>45 km</td></tr>
<tr><td>Tubli Bay IBA</td><td>~ 5 km</td><td>1.5 km</td><td>>5 km</td></tr>
</table>

11.2.2 Regional

Regional Protocols to protect the Arabian Gulf's marine resources include the Regional Organization for the Protection of the Marine Environment (ROPME); Bahrain is a member state. Of note is the Kuwait Regional Convention (adopted on 24th April 1978 and which entered into force on 1st July 1979); its protocols and action plans include the following:

- Action Plan for the Protection of the Marine Environment and the Coastal Areas of Bahrain, Iran, Iraq, Kuwait, Oman, Qatar, Saudi Arabia and the United Arab Emirates;
- Protocol concerning Regional Co-operation in Combating Pollution by Oil and other Harmful Substances in Cases of Emergency;

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[42] Note this table also includes nationally protected areas (highlighted with an *).
[43] These are not all protected, by default, under Bahrain legislation.
[44] IBA criteria A4i, B1i, B3.

- Protocol concerning Marine Pollution resulting from Exploration and Exploitation of the Continental Shelf;
- Protocol for the Protection of the Marine Environment against Pollution from Land-Based Sources; and
- Protocol on the Control of Marine Transboundary Movements and Disposal of Hazardous Wastes and other Wastes.
- The Convention on the Conservation of Wildlife and Natural Habitats in GCC Countries (2002), focuses on the conservation of ecosystems and wildlife, especially those species at risk from extinction, and aims to raise the standards of conservation of flora, fauna and natural habitats.

11.2.3 National

- Ministerial Resolution No. 70 of 2011 on defining the reclamation boundary of Tubli Bay, which includes the Ma'ameer Channel.

- Legislative Decree No. 21 (1996) and its subsequent amendments is the most significant national legislative document with regard to environmental protection of the territorial and marine environment from the potentially harmful effects of anthropogenic activities, particular reference is made to Article 27 which prevents the destruction of habitats and sanctuaries to marine life, and the following:
  - Ministerial Order (1986) for the protection of Dugong.
  - Legislative Decree No. 20 (2002) with respect to Organising the Fishing, Utilisation and Protection of Marine Wealth.

11.3 Assessment Methodology

11.3.1 Significance Criteria

Impact significance is 'calculated' as a product of sensitivity criteria (**Table 11.2**), and the magnitude of an impact (criteria defined later on in this section).

Sensitivity of marine habitats and/or species of note takes into account its rarity (e.g. IUCN Red List status, occurrence on a national scale), diversity, size, naturalness, vulnerability, representativeness and recoverability. Sensitivity criteria are devised to be consistent over extended periods; however, where natural habitats continue to be rapidly lost due to anthropogenic activities (e.g. reclamation), the value of these habitats and associated biota as sensitive receptors increases with time.

Table 11.2 presents the sensitivity criteria developed for marine ecological receptors.

Table 11.2 Marine Ecological Interests – Sensitivity Criteria

Scale	Sensitivity
High	The marine or coastal habitat(s) and/or one or more species (the 'receptor') within the potentially impacted area are of national and/or international importance, and may constitute, in part or whole, a national or internationally designated conservation/protected site and/or conservation priority species which is/are considered to be sparsely represented nationally and beyond. The habitat(s) may be an extremely good example of its type such as an intertidal flat, coastal lagoon, seagrass meadow or coral reef. The habitat(s) is likely to constitute a key primary producer and/or support highly diverse or unique assemblages of associated biota, including mammals (Dugong) and turtles and/or avifauna. The potential for the receptor to recover following physical disturbance is low (i.e. long term).
Medium	The marine or coastal habitat(s) and/or one or more species are of importance within a national context. The habitat(s) supports moderately diverse assemblages of epibiota, infauna and/or fishes. Examples of such marine habitats may include rock with sand veneer, patchy seagrass and macroalgal beds, and are representative of a largely undisturbed marine environment. The potential for the receptor to recover following physical disturbance is moderate (i.e. medium term).
Low	The marine or coastal habitat(s) and its associated species (the 'receptor') within the potentially impacted area are of lower importance as conservation features and/or primary producers, both locally and nationally, and may have been subjected to previous anthropogenic disturbance or be well represented as a national resource, for example, deep-water mud habitats. The habitat(s) may possess low biodiversity. The potential for the receptor to recover following physical disturbance is likely over the short term.
Negligible	The marine or coastal habitat(s) and associated biota, are of negligible national importance as a conservation feature, primary producer or exploitable resource as result of having been severely impacted by present and/or past anthropogenic activities. Examples of such degraded habitats may be within dredged areas in the marine environment or industrialised coastal fringes.

Quantifying the magnitude of an impact is defined via a number of sub-criteria. Typically these may be informed following specialist modelling studies (e.g. sediment dispersion modelling studies), expert opinion, review of contractor's methodologies, and reference to published data (e.g. sediment quality guidelines). Criteria include:

- **Extent:** whether the impact would occur onsite, in a limited (Li) area (within 1 km of the site); local (Lo) area (within, say, 5 km of the site or within the relevant Municipality); nationally (na) or internationally (in).
- **Duration:** whether the impact would be temporary (T-less than one year), short-term (ST-one to five years), medium term (MT-five to ten 10 years), long-term (LT-over ten years), or permanent (P).
- **Likelihood:** based on the best available information (primary and secondary data), the likelihood of an impact is assigned a classification based upon the probability of an event occurring (i.e. unlikely (U), likely (Li), and definite (De)).

- **Magnitude:** the quantifiable effects of impacts, measured where appropriate against an appropriate environmental standard (national, regional or international) or based on expert judgment.
- **Direct** (D): impacts that result from direct interaction between a project activity and the receiving environment (e.g. destruction of habitat beneath development footprint).
- **Indirect** (I): impacts that result from other activities as a consequence of the project (e.g. smothering of species at a nearby location as a result of deposition of suspended sediment generated by construction activity).

To calculate the level of significance, the formula presented below has been utilized.

Impact Significance = Magnitude of Impact x sensitivity of Receptor

Table 11.3 provides classifications of the resulting impact.

Table 11.3 Calculation of Impact Significance

MAGNITUDE	**High**	Minor/Moderate	Moderate	Moderate/Major	Major
	Medium	Minor	Minor/Moderate	Moderate	Moderate/Major
	Low	Negligible/Minor	Minor	Minor/Moderate	Moderate
	Negligible	Negligible	Negligible	Negligible/Minor	Minor/Moderate
		Negligible	**Low**	**Medium**	**High**
		VALUE AND SENSITIVITY			

Table 11.4 Scale of Impact Significance

Impact significance	Impact Description
Negligible	Very short term and of limited spatial extent typically limited to the immediate area adjacent to the source of impact. The loss is negligible and unlikely to register on a national scale.
Minor Adverse	Short term, temporary impacts where natural recovery is very likely over a very short time period (e.g. less than 1 year), or where the receptor has low level physiological responses to identified stressors (e.g. behavioural responses, etc.). The loss is small compared to national resources.
Moderate Adverse	Medium to long term (3-5 years) or spatial extent of the stressor (e.g. extent of plume) with regards its level of impact (e.g. lethality or physical damage). This may result in the displacement of species on a temporary basis.The loss represents a significant proportion of the national resource
Major Adverse	Long term (i.e. five years) or permanent loss of the receptor. Rrecoverability is unlikely even in the event of cessation of stressor. The loss represents a major proportion of the regional resource.

11.3.2 Survey Methodology

Subtidal marine environmental baseline surveys were conducted throughout the AOI during the months January 2016 - February 2016. Study areas are defined in **Figure 11.1**, and **Table 11.5**.

Table 11.5 Extent of Study Areas

AOI	Direct	Surrounding Area [45]
1	The direct study area for AOI 1 was defined as a 3 km radius from the centre point of the potential plume affected area[46]	• Ras Hayyan National Mariculture Centre • *Fasht al Adhm* • Al Dar Islands • Al Bader resort • Bahrain Yacht Club • Sitra Fishermans Wharf • Intakes and outfalls (Bapco, GPIC, Alba
2	The direct study area for AOI 2 is defined as a narrow corridor approximately 200 m X 500 m in the footprint of the pipeline crossing	• *Fasht al Adhm* • Al Dar Islands • Intakes and outfalls (as for AOI 1 and including the Sitra Power and Desalination Plant (SPDS)
3	The direct study area for AOI 3 is defined as a circle of 500 m radius centred around the Sitra Wharf area	• *Fasht al Adhm* • Intakes and Outfalls (as for AOI 1 and including Hidd and Ezzel, Bahrain Steel) • Khalifa Bin Salman Port • Mina Salman

A multi-tiered approach was adopted and included:

- A Drop-Down Video (DDV) survey, which provided a broadscale description of subtidal habitats. The use of DDV enabled the identification and mapping of seabed habitats and conspicuous epibiota over large areas without the need for divers, thereby enabling the rapid assessment of key marine ecological features. A system comprising a composite digital video camera (Deep Blue Pro) interfaced via an umbilical with an onboard laptop computer and hand-held 'Garmin GPS 12XL' system (Garmin International Inc., Kansas City, USA), was used. 2-dimensional (2D) habitat mapping was accomplished using ArcGIS, ArcInfo v.9.3 (Esri Inc., Redlands, USA).
- A comprehensive diver (Self Contained Underwater Breathing Apparatus / SCUBA) survey yielded qualitative and quantitative data on the benthic habitat types, conspicuous epibiota and fish encountered. Diver surveys included quantitative counts of epibiota present within three 1 m^2 quadrats, qualitative assessment and identification of conspicuous fauna and flora, fish identification and counts undertaken during the qualitative recording of epibiota Roving Diver Technique. Still photographs were taken using a Canon 'Digital rebel' EOS camera and ikelite underwater housing. All biota recorded during subtidal surveys were identified to species level where possible. Reference was made to a number of sources to assist in the photo identification of taxa unidentified *in situ* (e.g. Bosch *et al.*, 1995; Randall,

[45] Based on national requirements contained within the SCE's EIA -8 Guidelines on Key Mitigation Measures Pertaining to Reclamation Methodologies of Large-Scale Projects.
[46] Defined prior to modelling works based on discussions with HR Wallingford and relevant to the discharges from both outfalls.

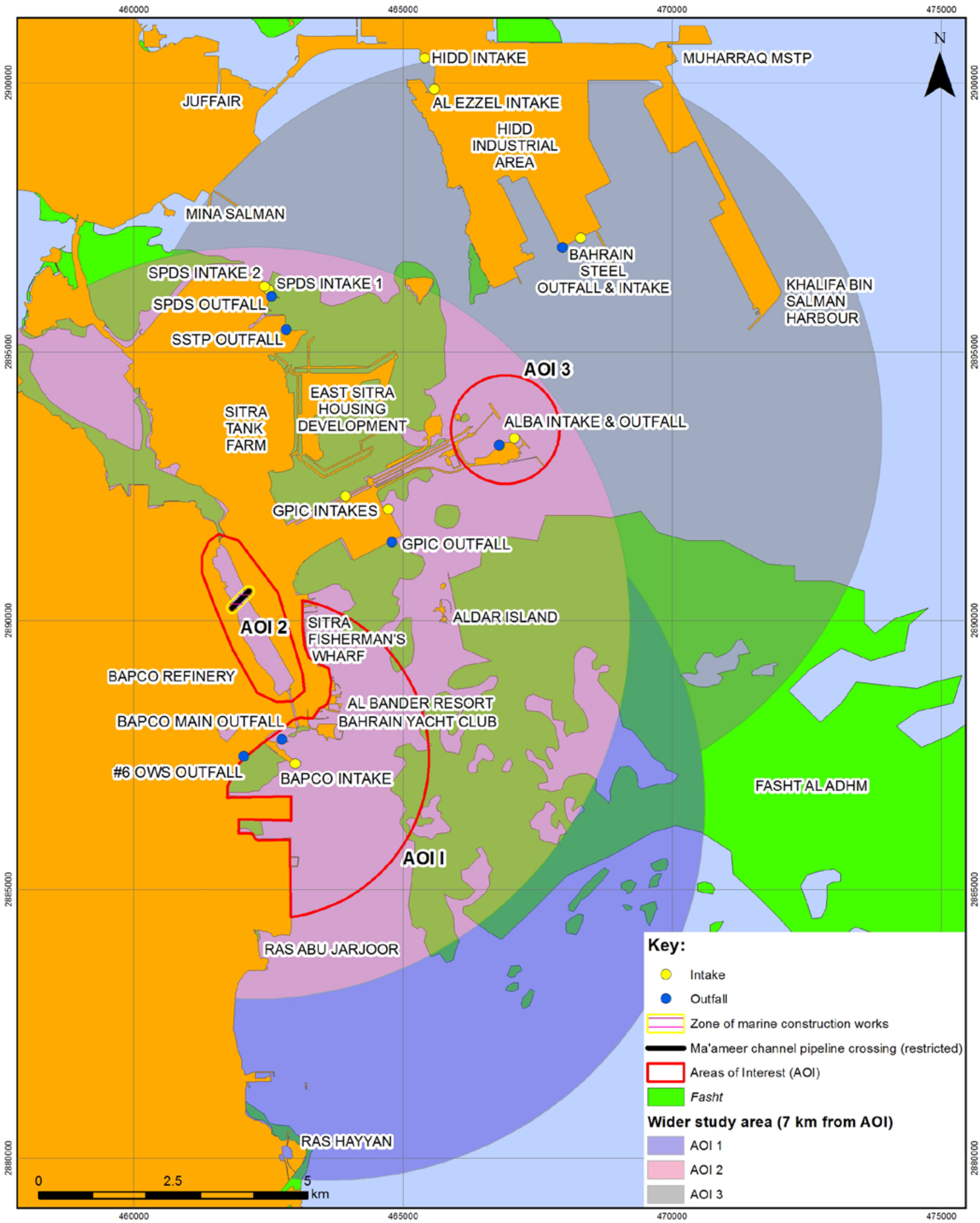
1995; Richmond, 2002, Carpenter *et al*., 1997). Once identified, all taxa were named based upon the nomenclature presented in the online database 'World Register of Marine Species' (WoRMS Editorial Board, 2015).

- Sediment samples were collected from strategic locations for infaunal identification and community analysis. At each station, three replicate grab samples were collected using a 0.05 m^2 Van-veen grab and immediately sieved. All material retained on the 0.5 mm mesh was transferred to plastic 'Ziploc' bags and preserved in 5% formalin solution. Samples were delivered in cool boxes to the laboratory (Al Reem Environment Consultation) where samples were stained with Rose Bengal prior to sorting under a magnifier. Identification was carried out using a Stereo Zoom Microscope (Radical Instruments, Ambala Cantt, India) fitted with a digital camera interfaced with a PC for identification to the lowest taxonomic resolution possible. Upon receiving the raw data, uni- and multi-variate statistical analyses to both characterise and identify similarities/differences in infaunal community diversity and composition between stations was conducted. The analysis was accomplished using the statistical software PRIMER 6 (PRIMER-E Ltd., Plymouth, UK).

A summary of the work conducted in each AOI is included in **Table 11.6**.

Table 11.6 Summary of Marine Ecology Investigations in the AOI

Work conducted	Area of Interest		
	AOI 1	AOI 2	AOI 3
DDV	55 locations (**Figure 11.2**)	-	38 locations
SCUBA	10 locations (**Figure 11.2**)	-	-
Walkover survey	-	✓	-
Infaunal sampling	8 locations	-	-



Title:		Client:
Extent of Study Areas		Bapco Technip
Project: Bapco Modernization Program		
Date: June 2016	Figure No.: 11.5	Consultant: Environment Arabia
Datum: WGS 84 - UTM 39N	Scale: 1:800,000 (A4)	

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11.4 Baseline

11.4.1 Secondary Data

11.4.2 Bapco Marine Environmental Assessment 2011 (Bapco, 2011)

Bapco (2011) encompasses all of AOI 1, and a larger area to the north, east and south of the Refinery.

The report notes the following:

"The shallow coastal area in front of the Bapco Refinery has a maximum depth of less than 10 meters. The sub-tidal ecosystem consists of a mixed soft bottom and coral rock/lime stone habitat. Relatively dense sea grass beds cover the areas with soft substrate where fish, shrimps and crabs are common. In the areas covered by rock, a few single colonies of coral are found.

The results of the Bapco 2011 marine environment assessment show a richer fauna in several of the stations in 2011 than in the earlier studies. In most of the stations, the number of species increased significantly, at some stations with a factor two or three. The results from the investigations of the benthic fauna in 2011 showed significantly more fauna, both in terms of number of species, diversity and abundance."

11.4.2.1 Adjacent Sensitive Habitats

In line with the SCE EA - 8 guidelines, the primary AOI have been investigated as per the methodology outlined in **Section 11.3.2**. In addition, the 'surrounding area' (defined as a distance of ~ 7 km from the study area in line with EA-8) was investigated by secondary data collection only.

Fasht al Adhm

The following is an extract from GEOMATEC (2006) MARGIS II:

Fasht al Adhm is marked as a high value area mainly due to the diversity of its habitats and the high productivity and diversity of its fishing grounds. Fasht al Adhm is well-known as the biggest fishing grounds in Bahrain and used by a large number of local fishermen (Abdulqader et al, 2004). The fisheries resources survey reported a large quantity of commercial fish catch from this area especially the Rabbit fish (locally known as Saffi). As with other fashts, the dominant habitat on the reef flat is hard rock substrate covered by sand and algae. There are patches of scattered seagrass as well, with a stretch of live corals existing along the northeast slopes of the fasht.

Tubli Bay

Wetland area (mangrove) - Tubli Bay MPA and Ramsar site

With a size of approximately 24 km^2 in the 1950's (Ghanem *et al* (2004)), Tubli Bay was known internationally for its unique ecology, providing a habitat for important coastal ecosystems including:

- Mangroves (*Avicennia marina*);

- Seagrass (*Halodule uninervis*, *Halophila ovalis* and *Halophila stipulacea*);
- Corals;
- Sandy shores (existing BDF[47] officer's club was at that time an individual sandy island);
- Rocky areas; and
- Mudflats (located predominantly along the eastern side of the bay).

The bay was considered to be the only area in Bahrain that contained all these coastal ecosystems, and represented an important nursery area for many species of fish (some of commercial value) and shrimp (Abdulqader, E.A.A. (1995)) (*Penaeus semisulcatus* and *Metapenaeus stebbingi*), as well as an essential site for thousands of migratory and resident bird species, Abdulrahman (1997).

Located towards the centre of the Bay, the island of Nabih Saleh provided an idyllic setting with dense palm groves, a rocky coastline on the west coast, and natural freshwater springs providing water for irrigation and bathing.

The coastline along Tubli fronted significant agricultural areas, with many vegetables and fruits grown beneath the canopy of once significant date palm plantations. Intertidal areas hosted significant floral communities and mangroves were dotted along the western side of the bay (extending towards the south-western coast of Sitra island), with the largest stand located at Ras Sanad. The reeds, *Phragmites australis,* and the rushes, *Juncus* sp., were also common, inhabiting the many drainage ditches that fed the bay with fresh water from the farm areas.

However, since that time, anthropogenic activities have severely impacted the ecology and geomorphology of the bay and this once ecologically unique ecosystem has been significantly degraded.

11.4.2.2 Megafauna (Marine Mammals and Turtles)

Marine mammals present in Bahrain's waters include cetaceans and the dugong (*Dugong dugon*). Cetaceans are represented by two regularly occurring species, namely the Indo-Pacific humpback dolphin (*Sousa chinensis*) and the Indian Ocean bottlenose dolphin (*Tursiops aduncus*) (Baldwin *et al*., 1999, Preen, 1989). There are also confirmed records of the finless porpoise in Bahrain (Baldwin *et al*., 1999).

The conservation status of these species, confirmed to occur in the study area (AOI 1 & 3), is provided in **Table 11.7**.

Table 11.7 Conservation Status of Marine Mammals within the Study Area[48]

Common Name	Scientific Name	IUCN Red List Category[49]
Finless porpoise	*Neophocaena phocaenoides*	VU
Long-beaked common dolphin	*Delphinus capensis*	DD
Indian Ocean bottlenose	*Tursiops aduncus*	DD

[47] Bahrain Defence Force.
[48] www.iucnredlist.org 2014.
[49] IUCN International Union for Conservation of Nature.

Common Name	Scientific Name	IUCN Red List Category[49]
dolphin		
Indo-Pacific humpback dolphin	*Sousa chinensis*	DD
Killer whale	*Orcinus orca*	DD
Dugong	*Dugong dugon*	VU

Codes are: DD – data deficient; VU - vulnerable

The most common species of turtles known to occur in the area of Bahraini waters included in this study are the green turtle (*Chelonia mydas*), and hawksbill turtle (*Eretmochelys imbricata*), which occur as foraging populations in shallow waters (Miller *et al.,* 1989; GEOMATEC 2006).

Two other species, the loggerhead turtle (*Caretta caretta*) and the Olive Ridley (*Lepidochelys olivacea*), also occur in the wider area, though with less frequency and in much lesser abundance (Miller, 1989). One other species has been documented for Bahrain, namely the leatherback turtle (*Dermochelys coriacea*) (Somer, 2003). This record is apparently historic and there are no contemporary sightings.

Preen's aerial survey results reveal a density of more than 0.3 turtles/km^2 in western Bahrain. These figures indicate a healthy population of turtles in the area, though density is lower than in other surveyed areas of the Arabian Gulf, such as the waters of the UAE where density was recorded as 0.87 turtles / km^2.

Population estimates have not been made, but can be expected to be relatively high, as the Arabian Gulf region generally supports some of the largest populations of feeding turtles in the world (Baldwin, 2005). All of the turtles that occur, or may occur in Bahrain are considered in danger of global extinction. The conservation status of these species is provided in **Table 11.8**.

Table 11.8 Conservation Status of Turtles in Bahrain[50]

Common Name	Scientific Name	IUCN Red List Category
Green turtle	*Chelonia mydas*	EN
Hawksbill turtle	*Eretmochelys imbricata*	CR
Loggerhead turtle	*Caretta caretta*	EN
Leatherback turtle	*Dermochelys coriacea*	CR
Olive ridley turtle	*Lepidochelys olivacea*	VU

CR – Critically Endangered; EN – Endangered; VU – Vulnerable.

Marine mammals and turtles are likely to occur in AOI 1 and AOI 3 (AOI 2 is too shallow and has restricted access), although no specimens were sighted during the marine survey.

11.4.2.3 Fisheries

In Bahrain, particularly the shallow waters within AOI 1, and adjacent *Fasht al Adhm*, represent important fisheries grounds. The area is host to a significant amount of Haddrah traps (fixed stake traps), gargoor (domed wire fish traps, see inset), and line

[50] www.iucnredlist.org 2014.

fisheries. *Fasht al Adhm* area is considered the 'best fishing ground' in the country according to Ministry of Municipalities and Agriculture (2007) Bahrain 2030 The National Plan, with significant shrimping grounds to the south of the study area. Together with the major shrimp fishery, where catches are dominated by the green tiger prawn *Penaeus semisulcatus*, wide varieties of finfish species are also caught.

The following sections provide a general overview of fishing practices in the Kingdom of Bahrain. An estimated 2,300 fishing boats operate within Bahrain waters. These are mainly fibreglass boats (85%), with the remainder (15%) comprising traditional wooden dhows. In 2004, over 2,727 registered fishing boats were operating in Bahrain waters; the fisheries sector supported 9,164 fishermen, of which 4,707 were full-time, and the remainder either part-time, recreational or occasional (PCMREW, 2006).

Traditional *gargoor fish traps*

Total capture fisheries production in 2010 was 13,490 tonnes (RECOFI, 2011). In 2012, the Bahrain fisheries sector was valued at a total of BD 13.161 million (m), including finfish (5,913 metric tonnes (MT), BD 6.991 m), crustaceans (6,809 MT, BD 5.875 m), and molluscs (264 MT; BD 0.295 m). In 1999, the agricultural sector, including fisheries, contributed less than 1% to the Bahrain's Gross Domestic Product (GDP) and employed about 4,770 people directly (Radhi *et al*., 1999) and about 700 indirectly (Uwate. R, 2000).

The main fishing gears used in Bahrain include shrimp trawls, gillnet, and wire traps of various sizes (*gargoor*), and hook and line. Many boats use a combination of fishing gear. In Bahrain, the shallow inshore area is also fished by fixed stake nets, known locally as *haddrah*. Fishing methods have varied little over time and can, with perhaps the exception of the shrimp fishery, still be termed 'artisanal'. Methods include *gargoor* (steel mesh trap), long line, gill nets and hook and line.

Appendix A of the MEBR provides a sequence of fisheries maps in the wider study area. The maps indicate the following fisheries in AOI 1: rabbitfish by gargoor rabbitfish by gillnet, on the eastern edge of the AOI on the edge of *Fasht al Adhm*, mullet by gillnet in the northern quarter of the AOI, halfbeak and needlefish by gillnet and crab fishing by gargoor. In addition the southern central area on AOI 1 is marked as an area for shrimp trawling. There are no significant fisheries interests in AOI 2 due to shallow water depths. Within AOI 3 the fisheries maps in the aforementioned MEBR appendix indicate that there may be some gargoor fisheries for rabbit fish (*Siganus* sp.), however none of the other fisheries are supported (crab, shrimp, lobster, needlefish, trevally, mackerel etc) which is supported by onsite observations.

11.4.3 Primary Data

11.4.3.1 Marine Habitats, Species Richness and Infauna in AOI 1

A total of 70 taxa were identified throughout the study area, using SCUBA, of which fish, flora and fauna accounted for 5, 20 and 45 respectively. **Figure 11.2** illustrates the number of taxa for each category at each of the 19 SCUBA survey stations.

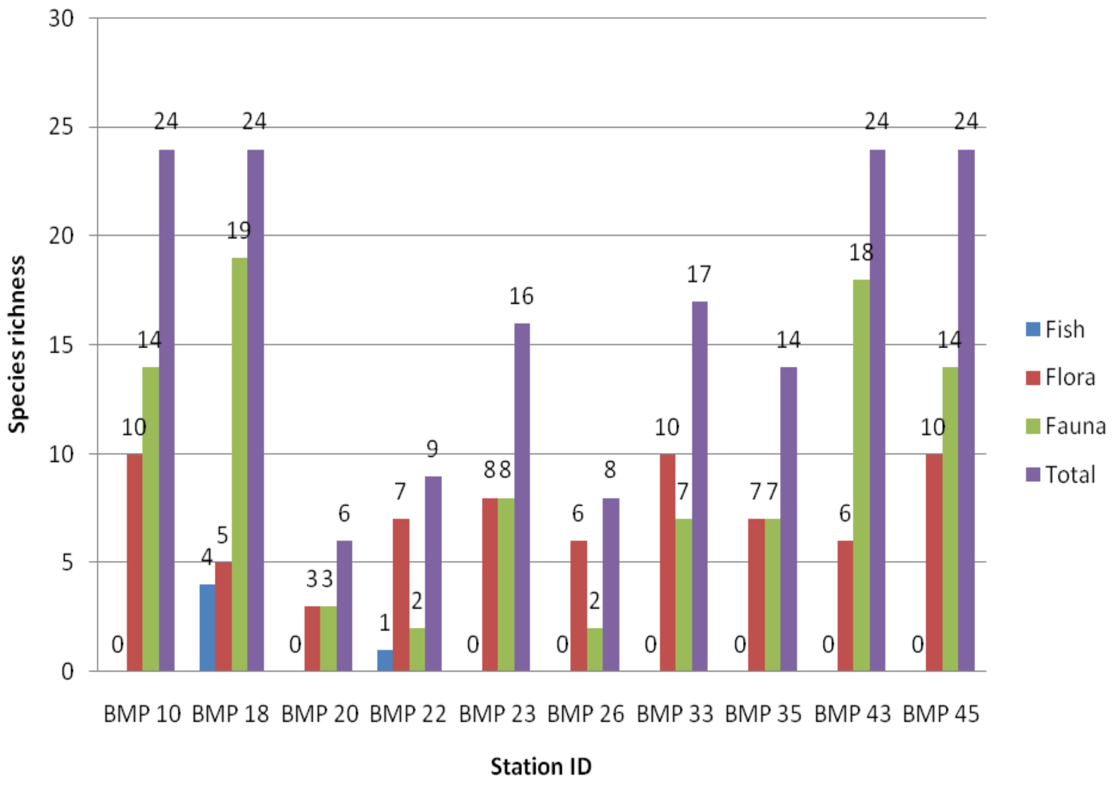
Four broadscale marine habitat types were identified within AOI 1. These have been summarised in **Table 11.9**.

Table 11.9 Marine Habitats Identified Within the Study Area

Habitat	Summary Description
Sand	Well-mixed sediment dominated by sand (fine-coarse). Topography varies from flat to undulating plain. Some green filamentous algae and mixed macroalgae present (~<5%). Some scouring evident on sediment surface in places.
Mud and sand	Muddy / sandy seabed, pits and burrows on the surface of the sediment. Some areas may have a thin layer of algal biofilm.
Mud	Muddy seabed with frequent distinctive pits and burrows on the surface. Some areas may have a thin layer of algal biofilm. Typically no conspicuous flora or fauna.
Coral, rock & sand[51]	Large rocky outcrops with areas with sand in between. Rocky areas have a mixture of epibiota including macroalgae, mixed bivalves, and scleractinian corals (coral cover variable and up to 60 % in places).

[51] Identified from the survey and SCUBA surveys.

Figure 11.2 Species Richness at SCUBA Survey Stations (AOI 1)

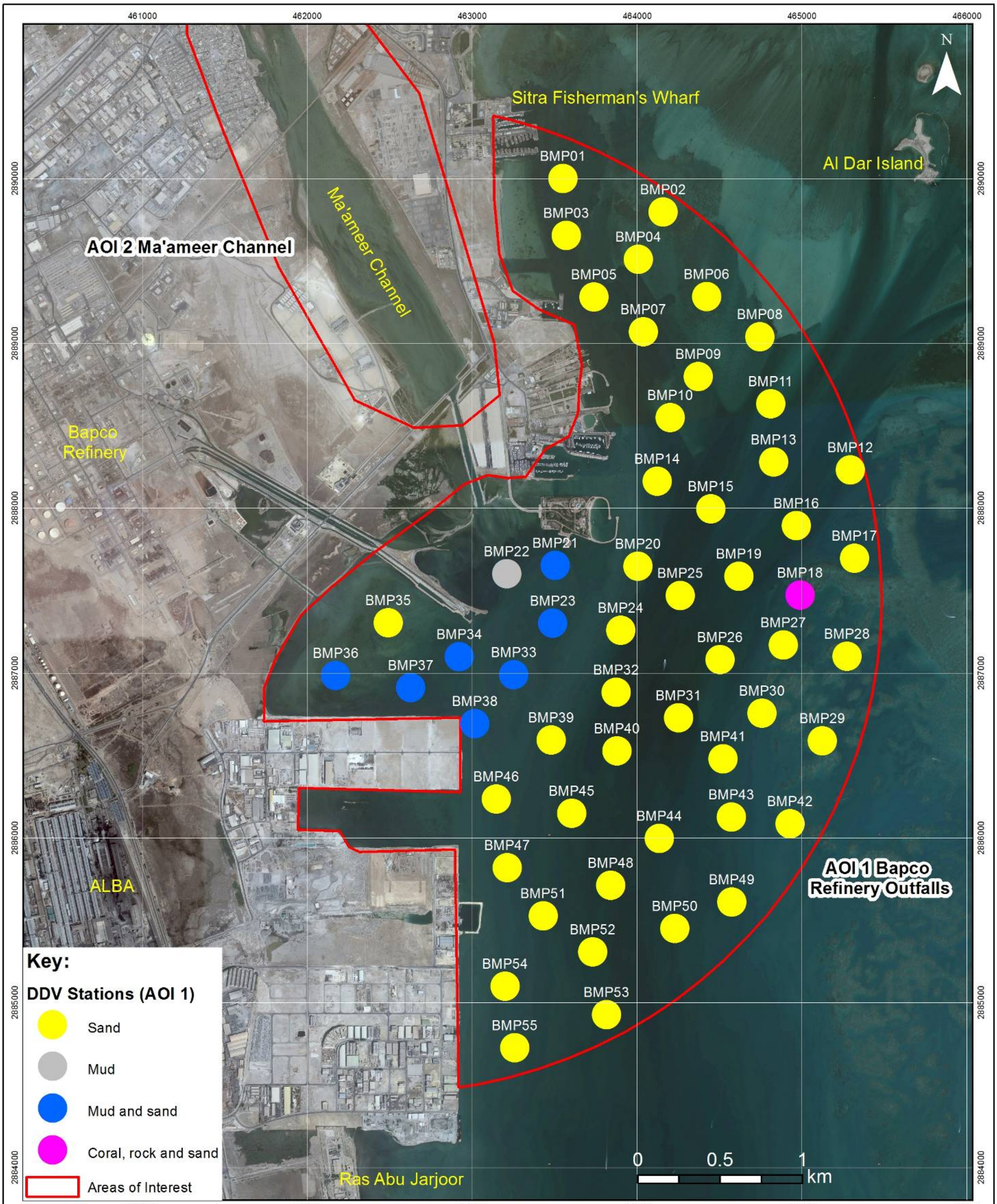


Infauna

1,103 organisms were identified in the 24 samples, spanning 37 taxa, from six phyla. As is commonly found, annelids, dominated the assemblage with 74.2% (818 organisms) of the total sample. Overall abundance was above average; with an equivalent average of 46 organisms per sample. The mean number of organisms per sample ranged from 18 in sample 20c to 92 in sample 33a.

Overall, diversity was considered to be average. Site 45 was the most diverse overall, returning the highest mean Margalef and Shannon-Weiner index values (d=4.85, H'=2.51). Comparatively, site 22 was particularly poor; mean diversity indices were generally low (d=1.76, H'= 1.25, J'=0.60). There was on average 10 taxa per site, site 22 had 8 while site 45 had 19. Grain size analysis suggests these sites have very dissimilar habitats, ranging from course sand to highly silty sediments.

The silt fraction of the majority of samples was reasonably low (ranging from 0.03 to 32), however site 22 was significantly high with a silt fraction of 0.88. Silt habitats, consisting of three sites, had a higher level of similarity (86.49%), which is unsurprising given the low number of sites included in this group. The species diversity was very low, shown by the group's low diversity indices (d=1.8, H'=1.3). The spread of species was very uneven. Three taxa dominated, together contributing 80% to the community type: the polychaetes *Prionospio* sp., *Armandia* sp. and Polychaeta (undet.). Coarse sand habitats had a higher species diversity in terms of the number of taxon (s=11) with a comparatively low number of individuals (n=2); therefore the species indices were fairly high (d=3.3, H'=2.1) suggesting a diverse but poor (in terms of individuals) community.



Title: Marine Habitat Map (AOI 1)		Client: Bapco Technip
Project: Bapco Modernization Program		
Date: February 2016	Figure No.: 11.2	Consultant: Environment Arabia
Datum: WGS 84 - UTM 39N	Scale: 1:50,000 (A4)	

CN:\Bapco Modernisation Plan\mxd\marine\Habitat map AOI 1.mxd

11.4.4 AOI 2 Marine Ecology Overview

Nine epifaunal species were recorded within three phyla and four classes were recorded within an area extending 100 m north and south of the proposed crossing and along the entire width of the channel. The majority of the specimens were molluscs (six taxa). The most commonly encountered gastropods were the ceriths (*Cerithium*) and *Pirenella* sp. typically associated with the mud/sand flats. Only a single crustacean taxa was recorded; the abundant small hermit crabs of the Family Paguridae which inhabited assorted empty gastropod shells (Paguridae Latreille, 1802). Barnacles (*Balanus* sp.) and *Spirobranchus kraussii* (Serpulid worms) were also observed, both of which were almost exclusively associated with palm trunks or other hard surfaces of debris deposited in the channel.

Several shoals of small fish were observed during the survey, on the shallow subtidal areas and it is likely that the channel plays an important role as nursery habitat for juvenile fish. The presence of goby burrows also indicates that the channel represents permanent habitat for these fish.

At least 10 flora species were observed, from 3 phyla and 7 orders, including the fringing mangrove trees (*Avicennia marina* (Forssk.) Vierh); these were assessed qualitatively by a local expert (**Section 12**) and determined to be sparse in nature (estimated at 1,600 m^2, within the defined study area).

The most notable type of algal specimens on site were large filamentous strands of robust green algae, most of which was most likely a mix of several species including *Chaetomorpha* Kützing, 1845, *Cladophora* Kützing, 1843 and *Ulva* Linnaeus, 1753 Spp. (2) in varying proportions.

Figure 11.4 provides a photomontage of a selection of site conditions to the South of the pipeline crossing at the Ma’ameer channel including some representative epibiota.

Figure 11.4 Photomontage from Walkover Survey in AOI 2

Image 1: View along the Ma'ameer pipeline crossing looking North East on the Southern side of the crossing. Image 2: The coastal fringe of the Ma'ameer channel has small mangrove trees (*Avicennia marina* (Forssk.). Image 3: During the walkover survey it was possible to completely traverse the Ma'ameer channel due to shallow waters immediately south of the pipeline crossing. Image 4: *Mitrella blanda* (G. B. Sowerby I, 1844). Image 5: View North towards the pipeline crossing which depicts the overall habitat in the main part of the channel – shallow muddy subtidal areas with patches of algae. Image 6: *Ulva* Linnaeus, 1753. Image 19: *Spirobranchus kraussii* (Baird, 1865) (LHS) and *Balanus* Costa, 1778 (RHS). Image 8: *Caulerpa sertularioides* (S.G.Gmelin) M.A.Howe, 1905.

11.4.5 Marine Habitats in AOI 3

Only 2 habitat types were identified in AOI 3 (extending a 0.5 km radius from the centre of works), ‘sand’ and ‘mud and sand’. The ‘sand’ habitat was identified at only 5 of the 38 locations surveyed (13 %) whilst the ‘mud and sand’ habitat was identified at the remaining 33 (87 %). Due to reasons of Health and Safety, no SCUBA surveys were undertaken in wharf area. The DDV survey was therefore designed to give a broadscale overview of the habitat types in the area.

Due to deep waters, (the average depth across the study area was 13.2 mBSL with a maximum depth of 16.5 mBSL recorded) and extremely strong currents, the quality of the video footage from AOI 3 is on the whole poor. This was magnified by presence of an extremely silty top layer to the seabed, which is easily disturbed resulting in extremely poor visibility. Nonetheless, it is evident from the review that both habitat types are characterised as having little or no conspicuous flora or fauna.

The following list provides a summary of the only conspicuous flora or fauna identified during the

1. Station SW 03: indet. filamentous algae (likely *Chaetomorpha* Kützing, 1845).
2. Station SW 09: indet. sea star observed (Asteroidea de Blainville, 1830).
3. Station SW 14: small clump of pearl oysters (appear to be live) (*Pinctada* Röding, 1798).
4. Station SW 26: possible tube anemone (*Cerianthus* Delle Chiaje, 1830).
5. Station SW 30: possible egg casing of the moon shell (Naticidae Guilding, 1834).
6. Station SW 37: Indet. sea star (possibly *Asterina* Nardo, 1834).
7. Drift algae (possibly *Spyridia filamentosa* (Wulfen) Harvey, 1833) at various locations.

Table 11.10 provides a summary of the two habitat types identified during the DDV survey. **Figure 11.5** presents still images from select survey stations.

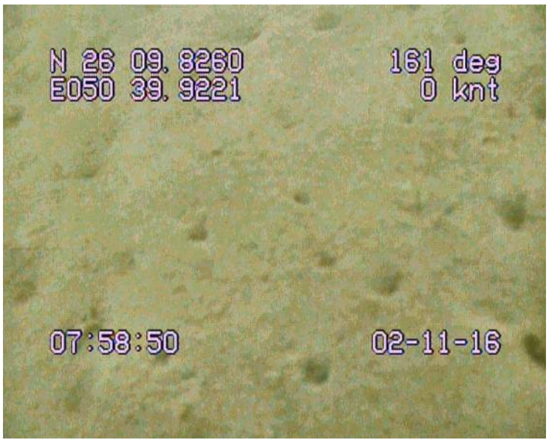
Table 11.10 Summary of Habitat Types from DDV Survey

Habitat type	Description
Mud and sand	Extremely silty seabed with no discernible conspicuous flora or fauna. Sediment surface has lots of pits and burrows. Slight algal biofilm visible in places.
Sand	Rippled sand with surface debris with some rubble on surface of sediment. No conspicuous flora or fauna. Extremely strong currents resulting in poor video quality.

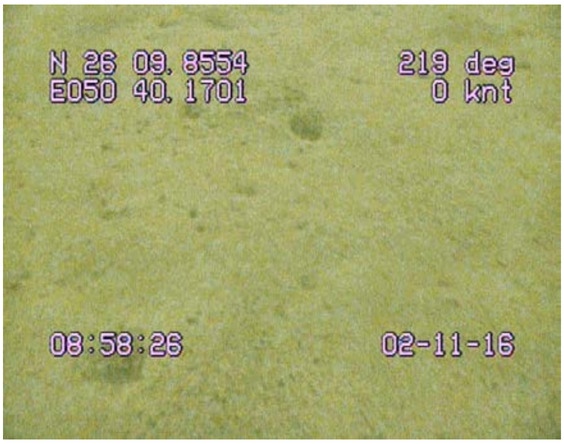
Figure 11.5 Key Features of the Seabed in AOI 3

SW01

SW30



SW10



SW22

11.5 Impact Assessment

11.5.1 Construction

The following sections provide an assessment of potential impacts arising from construction related activities. Detailed construction methodologies have not been provided at this stage; however, they are likely to include generic operations (e.g. excavation, reclamation, piling) from which impacts are well documented. Impact significance is based on the sensitivity criteria and magnitude of impact as defined in **Section 11.3.1** and is summarised in **Table 11.12**. As construction works will not take place within AOI 1, this area is not considered in the following sections.

11.5.1.1 Physical Destruction of Marine and Coastal Ecological Interests and Associated Biota due to Construction Activities

<u>AOI 2</u>

The extent of the 'impact zone' in AOI 2 (Ma'ameer Channel), for the purpose of this ESIA, is defined as a narrow band of approximately 500 m in width and 200 m in length (see **Figure 11.1**). This is estimated based on our understanding of the works (removal of existing pipe bridge, piling operations for new bridge construction and temporary reclamation works[52] required to facilitate works within the channel) and likely worse case extent of impacts arising from the suspension of marine sediments[53].

The subtidal zone within AOI 2 has been characterised by a silty sandy seabed with limited conspicuous epifauna; that which is present is largely limited to Cerith gastropods.

Primary productivity arising from macro algae is considered to be low given its paucity in the study area. The coastal fringe does, however host sparse density (~1,600 m^2) of *Avicennia marina*[54] mangrove trees (**Figure 11.4**); this species is reportedly hardy, fast growing and capable of fast regeneration (IUCN 2015). Nationally, mangrove stands have experienced diminished coverage over the last several decades[55], and hence are considered to be rare.

For the purpose of assessment, it is assumed that all ecological interests within an area of 10 hectares (ha) will be destroyed (note this is a conservative estimate), including the existing mangroves. The national coverage of mangroves is estimated at approximately 30 hectares (ha)[56], hence, the loss (complete loss of mangroves within the study area is most unlikely, however, is assumed as worse case) represents approximately 0.5% of the national population.

The sensitivity of the subtidal habitat and associated biota on site is considered medium based on the criteria highlighted in **Table 11.2**, however based on the protected status of the Ma'ameer channel, the sensitivity of the area is considered high. The geographical extent of the impact is low in relation to the national extent of the resources within.

The impact significance has been assigned as **minor to moderate adverse** primarily due to the presence of mangroves on site, and which may be at risk during construction works, but also taking into account the protective status (i.e. no reclamation allowed) of channel itself, and the loss of resources within the footprint of any reclamation[57]. The significance of potential impact can be reduced following mitigation (see **Section 11.6**).

AOI 3

The route of the proposed sealines in AOI 3 are highlighted in **Section 2**. Marine ecological interests in AOI 3 are considered to be of low sensitivity as it is a highly disturbed environment (dredged navigational channel) with little conspicuous flora or fauna (see **Section 11.4.5**).

Based on the temporary nature, extent and type of construction works (i.e. low magnitude of impact), and low sensitivity of the receptor, marine construction works have been assigned a **minor** adverse impact in AOI 3.

[52] A standalone SCE EA-4 Screening Form has been submitted to the SCE.
[53] Note: plume dispersion modelling was not deemed appropriate for this location and type of construction works.
[54] IUCN Red List - Least Concern.
[55] Pers comms Michael Arora.
[56] Rapid assessment of coverage by EACS (using Google Earth, 2016).
[57] A physical extent is not defined however is thought to consist a 10 m strip extending (at various times) across the width of the Ma'ameer channel.

11.5.1.2 Impact of Marine Sediment Loading (Suspended Solids) on Marine and Coastal Ecological Interests

Construction activities in both AOI 2 and AOI 3 have the potential to result in sediment loading of marine waters which has the potential to result in temporary adverse impacts (see **Information Box**[58] below) on those species which utilise specific feeding modes, particularly suspension/filter-feeding organisms, but also impairment of photosynthesis within macroalgal species and impeding respiratory functions of fish.

Information Box - Effects of Marine Sediment Loading on Marine Biota

- By decreasing the penetration of light into the water column, primary productivity can be diminished. The rate of respiration of phytoplankton can also exceed the rate of photosynthesis (Johnston, 1981).
- The introduction of fines into the marine environment (i.e. introducing organic matter and nutrients locked within the sediment) can 'bioload' the waters resulting in increased biological activity and temporarily reducing dissolved oxygen concentrations. This can have a knock-on effect on ecology, temporarily displacing motile organisms and/or impacting upon the health of others.
- Reducing the oxygen concentration of local waters by releasing oxidised material into the water column. In extreme circumstances this may give rise to anoxic conditions.
- Irritate or clog fish gills and interfere with fish feeding behaviour (Al-Ghadban and Price, 2002).
- Large quantities of suspended sediment in the water column can cause the loss of filter-feeding components of bivalves through clogging of the gills (Newell *et al*, 1998) furthermore, suspended sediment can also be detrimental to filter-feeding organisms due to the impairment of proper respiratory and excretory function and feeding activity (Sherk and Cronin, 1971).
- Physical abrasion of body and gills by sediment particles, resulting in the removal of protective mucus in fish and leading to infections and/or invasion by parasites (Everhart and Duchrow, 1970).
- Fish mortality as a direct result of exposure to elevated levels of suspended solids (sediment loading) may occur, threshold values at which lethal effects occur varying between different species (see Appleby and Scarratt, 1989).

<u>AOI 2</u>

Works will be temporary in nature; however, as the Ma'ameer Channel is tidal, the potential for sediment sediments arising from construction works (e.g. reclamation) to move up and down stream exists, although the presence of specific ecology susceptible to such plumes is minimal. The magnitude of impact is, however, considered low (based on our understanding of potential construction works) and temporary in nature hence a **minor adverse** impact is assigned.

<u>AOI 3</u>

[58] Note this is not an exhaustive list but one specific to organisms found within AOI 2 and AOI 3.

The potential impact of elevated TSS on adjacent sensitive receptors is considered very low given the works are largely non-obtrusive, and the paucity of sensitive marine receptors within the near vicinity (the area is industrial in nature and the seabed has been dredged; the nearest sensitive receptor of *Fasht al Adhm* is approximately 2 km to the south east and generated plumes from construction works will likely not extend 50-100 m[59]). Consequently a **negligible adverse** impact is assigned.

The significance of impact, due to production of suspended sediment plumes, would likely increase should the method of pipeline installation require dredging works; note this has not been assessed and would likely require sediment plume dispersion assessment.

11.5.1.3 Impact of Noise on Megafauna and Fish

Sound plays a very important role in the lives of marine mammals and fish, and, to a lesser extent, turtles. As such there is some concern that they may be negatively impacted by sounds, it is unlikely that this project will result in noise that could cause immediate or delayed fatal injury, associated with piling/decommissioning/dredging/ vessel movements, etc. The possible effects on marine megafauna and fish can be placed into the following four categories (Gordon et al., 2004):

- Physical (including physiological) effects: to include damage to body tissues, gross damage to ears, Permanent Auditory Threshold Shift (PTS), Temporary Auditory Threshold Shift (TTS) with eventual recovery, and chronic stress effects that may lead to reduced viability;
- Perceptual effects: including masking of biologically significant sounds (e.g. communication signals, echolocation (in odontocetes), and sounds associated with orientation, finding prey or avoiding natural or manmade threats);
- Behavioural effects: including disruption of foraging, avoidance of particular areas, altered respiratory patterns, and disruption of mating systems; and
- Indirect effects: including reduced prey availability resulting in reduced feeding rates.

Marine construction works are limited to AOI 2 and AOI 3 only; these are not expected to be large-scale or intensive and in both areas, are of short duration. Noise generation expected from such operations is identified in **Table 11.1**.

Table 11.11 Piling Noise Characteristics (Government of South Australia, 2012)

Piling method	Character	Noise descriptor	Source levels	Most energy
Impact	Impulsive	SEL	170–225 dB re 1 μPa^2·s	100 Hz and 1 kHz
		SPL	180–235 dB re 1 μPa	
		Peak level	190–245 dB re 1 μPa	
Vibro-driving	Continuous	SPL	160–200 dB re 1 μPa	100 Hz and 2 kHz

- Sound pressure level (SPL) – average noise level over the measurement period expressed in dB re 1 μPa. For impulsive sources, such as impact piling and blasts, the measurement period is the

[59] Information based on discussions with experts in the field including those involved with dredging activities and hydrodynamic modellers.

time period that contains 90% of the sound energy (Southall *et al*. 2007). Continuous sources, such as vibro-piling and shipping, are commonly described in terms of an SPL.

- Sound exposure level (SEL) – Total noise energy over the measurement period expressed in dB re 1 $\mu Pa^2 \cdot s$. The SEL is commonly used for impulsive sources because it allows a comparison of the energy contained in impulsive signals of different duration and peak levels.
- Peak level – Maximum noise level recorded during the measurement period expressed in dB re 1 μPa. The peak level is commonly used as a descriptor for impulsive sources.

AOI 2

Cetaceans and turtles cannot frequent AOI 2 due to shallow water depths and restricted access, hence **no impact** is assigned in this regard.

Fish observations during the walkover survey were limited to indeterminable fry suggesting that the channel may serve a role as a nursery area for specific species.

In the case of fish, the impact may be highly variable due to the range of species and their differing sensitivity to noise exposure. However, at the noise levels predicted for this project (**Table 11.1**), impacts on many fish species would most likely include reduced local abundance (due to temporary displacement) (Dalen & Raknes, 1985; Dalen & Knutsen, 1987). Given the ability of most fish to take action to physically avoid noise, it is unlikely that any species will experience pathological effects or even permanent physiological changes. The only exception is for egg and larval stages where these are at high concentrations; this has not been determined within the scope of this study.

Given the scale and temporary nature of works within AOI 2, a precautionary **negligible to minor adverse** impact is assigned.

AOI 3

No cetaceans or turtles were sighted during the subtidal survey, however dolphins, and during at least one occasion[60] Killer Whales (*Orcinus orca*), are regularly observed both within, and adjacent to AOI 3[61]. It is possible that turtles rarely pass through the work site but is considered extremely unlikely. Dugongs are not known in inhabit the study area, with populations mainly restricted to the south east, western and northern marine areas of Bahrain Preen (1989); however the presence of individuals passing nearby areas cannot be ruled out.

AOI 3 is industrial and serves a number of commercial jetties which large vessels frequent. The presence of main navigation channels within AOI 3 result in constant levels of background noise which, according to EACS observations, does not result in dolphins vacating the area; on the contrary dolphins are often observed within close proximity of dolphin watching tour boats.

Works within AOI are restricted to minor trenching and backfilling works, typical noise generation is not estimated. However, to put possible impacts in perspective, a typical marine mammal in the area (e.g. the relatively common Indian Ocean bottlenose

[60] In the year 2004 at least two whales spotted adjacent to the GPIC jetty.

[61] Dolphin watching tours in Bahrain regularly target the area to the south of the GPIC. EACS has observed both the Indo-Pacific humpback dolphin (*Sousa chinensis*) and the Indian Ocean bottlenose dolphin (*Tursiops aduncus*) in the study area over the past decade.

dolphin) could sustain auditory injury within 100 m of heavy pile-driving activity and behavioural disturbance, defined as modifications in behaviour, could occur at a distance of several tens of kilometres away (perhaps up to 50 kms). Beyond this distance, it is likely that the noise from construction will no longer be distinguishable from background noise levels.

For dugongs less published information is available, but it can be reasonably postulated, given a limited amplitude of calls within high frequencies resulting in low detection ranges, that the dugong ear will be quiet sensitive to impact. It is also likely that the vocalisations will be easily masked leading to interference with inter-individual communication where radiated noise sources are above 130 dB 1µPa (Ichiwaka, 2012).

Even less information is available for turtles, but McCauley *et al*., (2000) took data collected by O'Hara and Wilcox (1990) and calculated that the level they saw avoidance was also around 175–176 dB re 1 µPa (note that this was measured as rms (continuous sound), rather than impulsive sound, but at least demonstrates detection and sensitivity). The authors concluded that marine turtles are likely to show behavioural changes at around 2 km and an avoidance reaction 1 km. A similar level of impact is considered likely in this case.

Impact assessment has been made on the likely presence of receptors and in this regard it is considered most unlikely that dugong and/or turtles will be present within the immediate area of influence; hence impacts upon dolphins is made.

Dolphins, including the Indo-Pacific Humpback, *Sousa chinensis*, and Indian Bottle Nose *Tursiops aduncus,* are likely to have become habituated to high levels of existing background noise, and due to their highly mobile nature, individuals are likely to avoid the area if levels become a nuisance. Subsequently a **negligible** adverse impact is assigned; a similar impact on fish is assigned (the area under the influence of works is not considered as key in hosting fish populations).

11.5.1.4 Risk of Collision of Work Vessels with Megafauna

AOI 2

No impact assigned as both megafauna and vessels are not present within the channel.

AOI 3

The presence of dolphins, during marine construction works is likely. Collisions with vessels/propellers do pose a risk of injury, however, as stated earlier, the AOI is industrial in nature and dolphins are likely to have become habituated to vessel engine noise and subsequently avoid the area when affected.

Vessels associated with construction works will typically be slow moving, this combined with the mobile nature of dolphins, and the paucity in turtle and dugong populations in the area results in a **negligible** adverse impact to be assigned.

11.5.1.5 Impact of Spillages of Fuels on Marine and Coastal Ecological Interests

Marine organisms are known to be highly sensitive to diesel spills. Diesel is considered to be one of the most acutely toxic oil types (NOAA 1999). The chemical components light oils such as diesel have a higher biological availability and damage through toxicity is more likely than for heavy fuel oil (HFO) (ITOPF, undated). However, small diesel spills in open water are rapidly diluted and fish kills have never been reported following such incidents. Fish kills following small diesel spills have only been reported for small spills in confined, shallow water (NOAA, 2006).

Since diesel floats on the water's surface, benthic habitats and biota within the subtidal waters of the study area are unlikely to be adversely affected as a result of a limited release and an impact significance of **negligible to minor** adverse is assigned for both AOI 2 and AOI 3.

Table 11.12 Construction Impact Summary Table – Marine and Coastal Ecological Interests

Description of Impact	AOI	Receptor sensitivity	Features of impact				Type of impact (D,I,S[a])	Impact significance	Residual impact (following mitigation)
			Magnitude	Extent	Duration	Likelihood			
Physical Destruction of Marine and Coastal Ecological Interests and Associated Biota due to Construction Activities	AOI 2	M-H	L	Lo	T, P	Li	D	Minor/Moderate	Minor
	AOI 3	L	L	Lo	T	Li	D	Minor	Minor
Impact of Marine Sediment Loading (Suspended Solids) on Marine and Coastal Ecological Interests	AOI 2	M-H	L	Onsite	T	Li	D,I	Minor	Negligible/Minor
	AOI 3	L	N	Lo	T	Definite	D,I	Negligible	Negligible
Impact of Noise on Megafauna	AOI 2	H	-	-	-	-	-	Negligible	No Impact
	AOI 3	H	N	Lo	T	U	D,I	Negligible	Negligible
Impact of Noise on Fish	AOI 2	H	N	Lo	T	U	D	Negligible/Minor	Negligible
	AOI 3	H	N	Lo	T	U	D	Negligible	Negligible
Risk of Collision of Work Vessels with Megafauna	AOI 2	H	-	-	-	-	-	No Impact	No Impact
	AOI 3	H	N	Lo	T	U	D	Negligible[62]	No Impact
Impact of Spillages of Fuels on Marine and Coastal Ecological Interests	AOI 2	H	N	Lo	T	U	D,I	Negligible/Minor	Negligible
	AOI 3	H	N	Lo	T	U	D,I	Negligible/Minor	Negligible

LT – Long Term, L-Low, H-high, N-negligible, Lo-local, T – temporary, M-medium, De-definite, U-unlikely, D-direct, I-indirect, S-secondary. Li-likely "-" – No values assigned / does not occur

[62] Risk significance (based on occurrence in study area).

11.5.2 Operation

11.5.2.1 Routine Operation Post BMP

AOI 1

Impacts upon marine ecological receptors within AOI 1 have already occurred, and are associated with past and ongoing Refinery operations. The BMP will not affect effluent characteristics or volumes, hence, no additional impacts upon marine ecological receptors are expected, other than that which has already occurred (i.e. **no impact**). Specialist studies (e.g. dispersion modelling, baseline surveys) were conducted to assess the area of influence and past impacts, and from which future monitoring programmes could be based.

The following sections provide a discussion on existing impacts largely focussing on temperature related impacts.

Review of Bapco (2011) and primary data collected as part of this assessment, indicates that noticeable impacts upon marine ecology is largely restricted to nearshore shallow water habitats where water currents are lower, and dispersion is reduced. The physical characteristics of sediments (i.e. silt) at station BMP 22 confirms the quiescent nature of the bay. Bapco (2011) confirms the physical properties of seabed sediments at this location.

Onsite observations (EACS, 2016) indicate that habitats adjacent to the main outfall are clearly affected whereas those associated with OWS#6, significantly less so. This is despite the modelling showing that both are likely to experience excess temperatures over ambient in the region of 5-10°C.

Review of infaunal communities indicates that species diversity was considered to be average across the study area, as is commonly found in medium grained sand, however, site 22 was particularly poor; mean diversity indices were generally low (d=1.76, H'= 1.25, J'=0.60)[63]. As a comparison, BMP 45 hosted between 12-15 species, whereas BMP 22 ranged between 5-8 (the lowest recorded across the study area). Station BMP 35 (close to OWS#6) hosted between 9-10 species.

BMP 22 - dominance of polychaete worms

Furthermore, dense populations of filamentous algae (an indicator of thermal pollution) were noted throughout the duration of surveys at the location of the main outfall, whereas similar coverage was not noted at OWS#6.

[63] Three taxa dominated at this site together contributing 80% to the community type: the polychaetes *Prionospio* sp., *Armandia* sp. and Polychaeta (undet.). Typical signs of ecological degradation are a decline in diversity and dominance of indicator species.

Figure 11.6 Dense Coverage of Filamentous Green Algae at BMP 22

Temperature can have an influence on the growth and reproduction of marine species. Initially, mobile species such as plankton and fish are most likely to be affected by changes in seawater temperature (Hiscock *et al.*, 2004). In general temperature affects the density, osmotic pressure and buffering properties of seawater, and the supply of dissolved oxygen (Kinne, 1964). In areas where mixing/dispersion is good, deleterious effects are largely mitigated, although where quiescent areas prevail (i.e. adjacent to the main outfall) impacts are likely. Vousden, (1995) reported that discharges into the marine environment from industrial facilities[64] in Bahrain "may not represent a problem with regard to temperatures as they do not significantly raise the ambient water temperature above local summer values".

Increased water temperatures can stimulate the rate of photosynthesis, which stimulates floral growth. This can, in extreme circumstances lead to algal blooms, or an increased rate of growth by more thermally tolerant species. An increase in primary producers can lead to a reduction of oxygen levels in the water column. These observations were noted in areas adjacent to the main outfall with a high coverage of filamentous green algae, but less so at OWS#6 and not observed elsewhere.

It is also possible that increases in water temperatures can lead to an increase in susceptibility to disease and / parasites from changes in physiological function. The toxicity of chemicals in the marine environment may be increased at elevated temperatures; again review of Bapco (2011) show a higher level of historic contamination of hydrocarbons in nearshore areas.

The localised impact of temperature increase may be more pronounced in summer months, as the local flora and fauna may be nearer to their upper tolerance in summer months (summer water temperatures frequently reach 36°C[65]. Generally, studies of temperature effects on tropical organisms indicate that temperatures around 35°C are critical or lethal (Nour El-Din, 2004).

Review of the data sets indicate that the extent of thermal pollution is rather localised and doesn't conspicuously extend more than approximately 300 m radius from the main outfall bay outlet and less so for OWS#6.

[64] Reference was made to Reverse Osmosis plants, however the principle applies to any facilities that results in the discharge of excess temperatures such as the Bapco Refinery.

[65] EACS observations (2002-2016).

EACS (2016) recorded the presence of seagrass (*Halophila ovalis* and *Halodule uninervis*) in low coverage (typically up to 3%), and sporadically across the study area (away from the outfall areas - stations BMP 33, BMP 35 located from the main outfall and OWS#6, ~900 m and ~500 m respectively). Species such as *Halodule uninervis* exhibit a high tolerance to elevated temperatures and are observed in intertidal areas nationally. *Halophila ovalis* is reported to possess both a wide biogeographic range and broad temperature tolerance (Ralph, 1998). Both species may survive seawater temperatures in excess of 39 °C (McMillan, 1984) and hence the presence of seagrass is not likely to be directly impacted by thermal discharges.

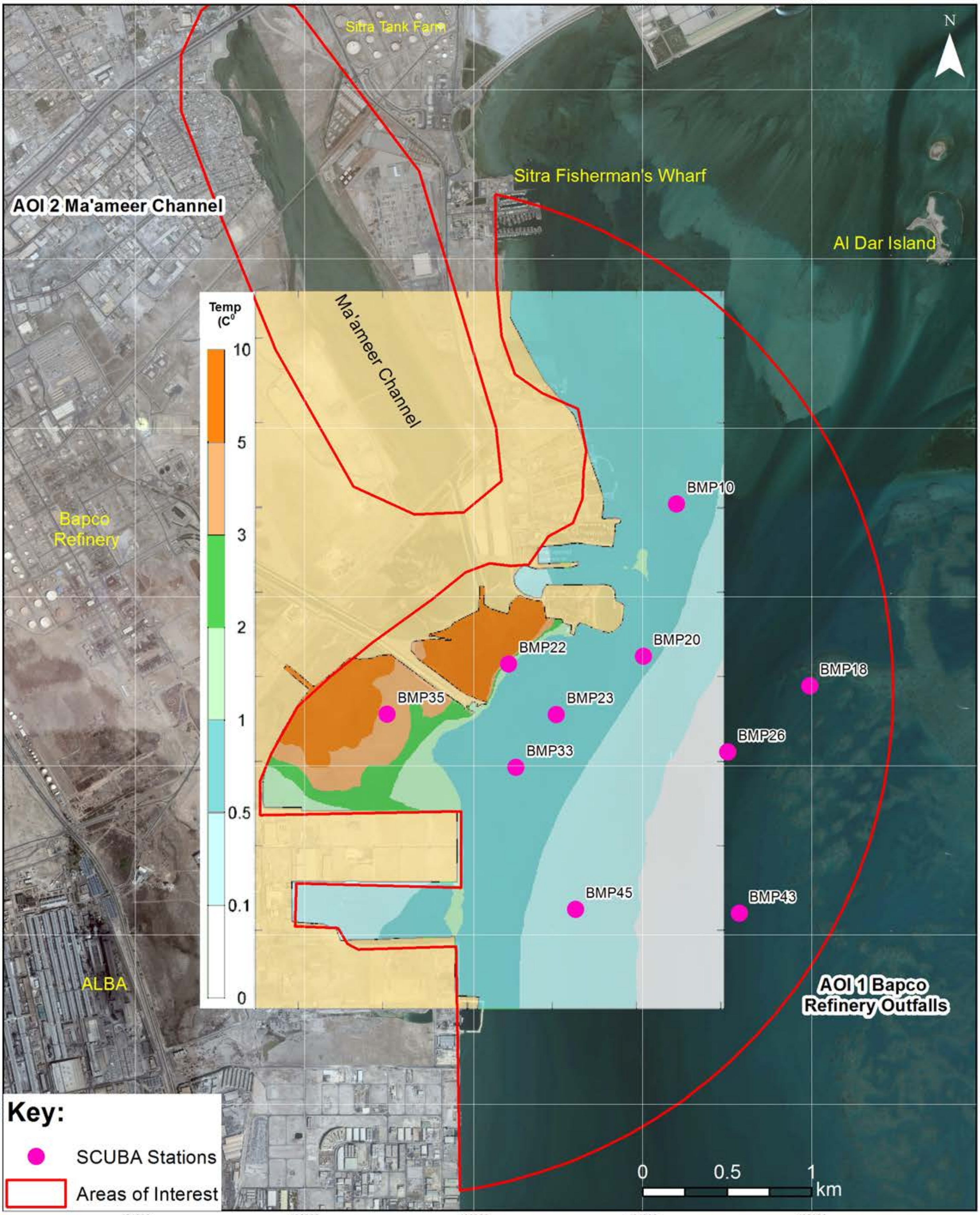
Although the majority of AOI 1 comprised sand and mud and sand a single location (BMP 18) was located on the edge of *Fasht Al Adhm* and contained numerous rocky outcrops with live coral attachment. This station, which is representative of the *fasht* areas to the east, was identified as ‘Coral, Rock and Sand’ habitat according to the definitions highlighted in the Bahrain Marine Habitat Survey (Vousden, 1988) and the MARGIS II habitat survey (GEOMATEC, 2006).

The CRS habitat is essentially a bedrock environment with patches and/or gullies of sand in between; the depth of the sand is often variable, with deeper patches occurring between exposed bedrock, the latter providing a suitable substrate for the attachment of hard corals, macroalgae, hydroids and bivalves, amongst other epibiota. Several species of hard coral were recorded in this habitat including stony corals and massive starlet corals[66]. The presence of corals, despite its large scale extirpation from Bahrain's waters, is a clear sign that this area is not being adversely impacted by thermal plumes.

<u>AOI 2 and AOI 3</u>

Routine operations post BMP will have **no impact** on marine and coastal ecological interests within AOI 2 or AOI 3.

[66] *Siderastrea savignyana* Milne Edwards & Haime, 1850, *Platygyra* Ehrenberg, 1834 *and Porites harrisoni* Veron, 2000.



Title: **Maximum Average Thermal Plume Results for a Weak Wind at the Seabed during a Neap Tide**			Client: Bapco Technip
Project: Bapco Modernization Program			
Date: May 2016	Figure No.: 11.4		Consultant: Environment Arabia
Datum: WGS 84 - UTM 39N	Scale: 1:30,000 (A4)		

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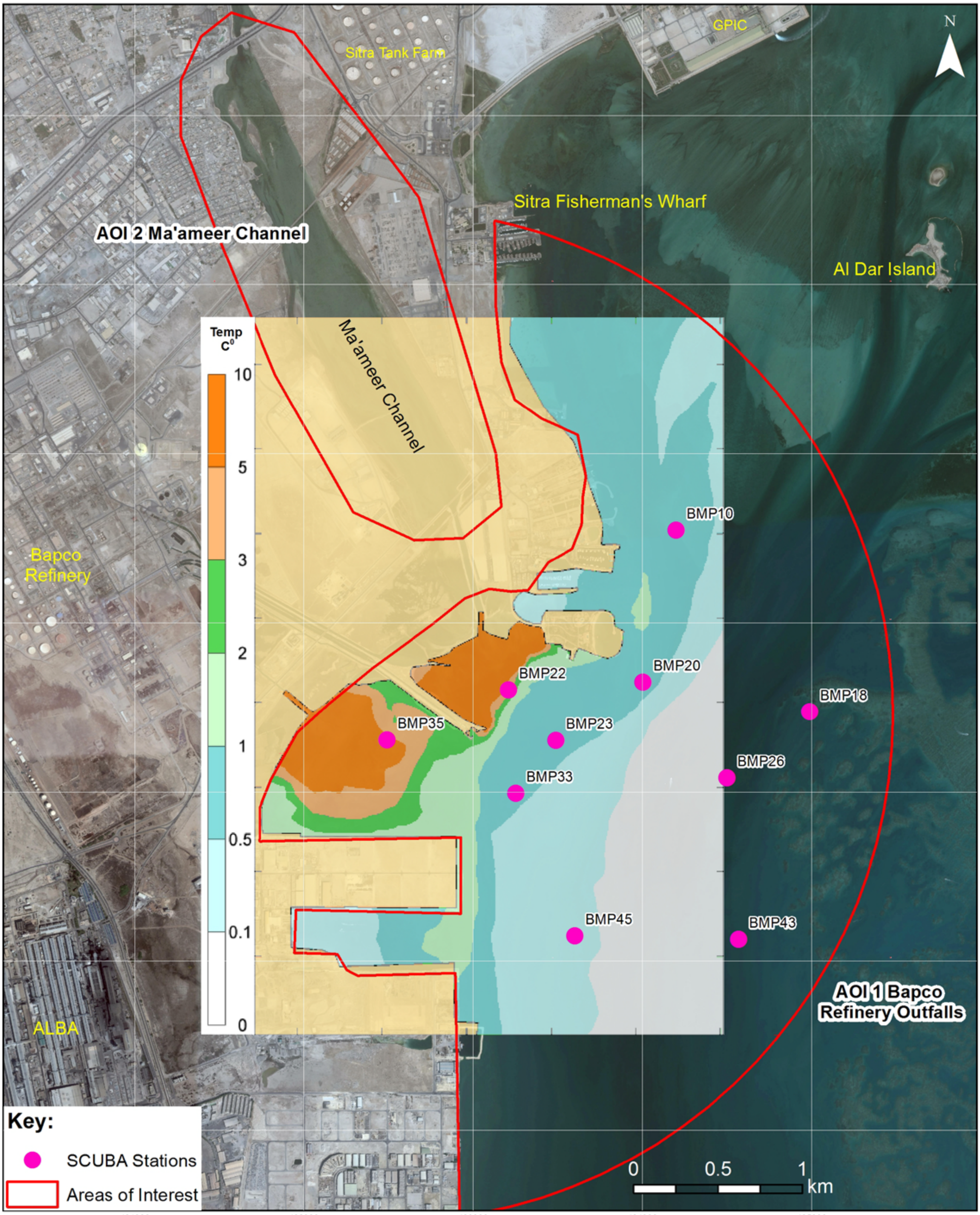

Title: Maximum Summer Thermal Plume Results for a Weak Wind at the Seabed during a Neap Tide			Client: Bapco Technip
Project: Bapco Modernization Program			
Date: May 2016		Figure No.: 11.5	Consultant: Environment Arabia
Datum: WGS 84 - UTM 39N		Scale: 1:30,000 (A4)	

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11.6 Mitigation and Monitoring

11.6.1 Construction

AOI 1

There will be no construction works conducted at this location hence there is no requirement for mitigation or monitoring.

AOI 2

Marine construction impacts will be confined to a narrow corridor (approximately 200 m X 500 m, see **Figure 11.1**, defined as the 'work zone'). The most appropriate mitigation is as follows:

- Fully contain the work zone, with silt curtains (i.e. north and south of the works area).
- However, additional mitigation should be implemented into contractor's methodology and as identified in **Section 9.8.1.2** (Hydrodynamics and Water Quality) which includes recommendations for storage of fuels, waste management,
- Ensure that an appropriate TSS monitoring protocol is established (this has been detailed in the CESMP).
- Despite the small footprint of the work zone in the Ma'ameer Channel, specimen relocation (and/or consider planting of saplings) should be considered if any of the mangrove trees are within the footprint as it is likely that within the Ma'ameer channel itself there is sufficient space for additional specimens.

AOI 3

Impacts on marine ecology during construction activities in AOI 3 are predicted to be minimal (see **Section 11.10**). As with AOI 2, mitigation covered in **Section 9.8.1.3** Hydrodynamics and Water Quality:

- Attempt to avoid trenching works; if this is unavoidable select methods that result in the least disturbance of seabed sediments (e.g. closed clam shell buckets) and ensure that excavated material is not dumped to sea.
- Should covering of trenches be required, use suitable material with low fine content. Adhere to Deltares (2008) Land Reclamation Manual. Ministry of Works.
- Ensure appropriate fuel/oil spill mitigation is in place and appropriate to the size of vessels employed.
- In addition, due to the possibility that cetaceans or turtles might be present in the study area, visual monitoring of marine mammals (and turtles) by crew[67] may also confirm presence in the study area so that they can be avoided. This should be conducted on a daily basis and records kept for monitoring purposes. All crew should be vigilant for presence of sensitive species.

[67] Dedicated Marine Mammal Observers (MMO) are not deemed necessary as the work area is within a Wharf area.

11.6.2 Operation

The Bapco Refinery may wish to look at ways in which the cooling water temperature is reduced prior to discharge to sea; however, this is likely to be cost prohibitive and beyond the scope of this ESIA. Bapco (2011) provides information on the ecology adjacent to the two outfalls every 5 years, and the results show that the marine ecology in the study area AOI 1 has improved over the 30 year period since the survey commenced (see **Section 11.4.2**). It is recommended that this survey programme continues, and perhaps increases in frequency and SoW.

11.7 Summary

Table 11.13 provides a summary of impacts for marine ecology.

Table 11.13 Summary of Marine Ecology Impacts

<table>
<tr><th>Impact</th><th>Nature of Impact</th><th>Significance</th><th>Mitigation/Enhancement Measures</th><th>Residual Impact</th></tr>
<tr><td colspan="5">Construction</td></tr>
<tr><td>Physical destruction of marine and coastal habitat – AOI 2</td><td>Permanent</td><td>Minor to moderate adverse</td><td rowspan="6">Attempt to avoid trenching works; if this is unavoidable select methods that result in the least disturbance of seabed sediments (e.g. closed clam shell buckets) and ensure that excavated material is not dumped to sea.
Should covering of trenches be required, use suitable material with low fine content. Adhere to Deltares (2008) Land Reclamation Manual. Ministry of Works.
Ensure appropriate fuel/oil spill mitigation is in place and appropriate to the size of vessels employed.
Fully contain the work zone, with silt curtains (i.e. north and south of the works area).
Refer to Section 9.8.1.2 (Hydrodynamics and Water Quality) which includes recommendations for storage of fuels, waste management.
Ensure that an appropriate TSS monitoring protocol is established.
Despite the small footprint of the work zone in the Ma’ameer Channel, specimen relocation (and/or consider planting of saplings) should be considered if any of the mangrove trees are within the footprint as it is likely that within the Ma’ameer channel itself there is sufficient space for additional specimens.</td><td>Minor adverse</td></tr>
<tr><td>Physical destruction of marine and coastal habitat – AOI 3</td><td>Permanent</td><td>Minor adverse</td><td>Minor adverse</td></tr>
<tr><td>Impact of marine sediment loading – AOI 2</td><td>Temporary</td><td>Minor</td><td>Negligible/Minor</td></tr>
<tr><td>Impact of marine sediment loading – AOI 3</td><td>Temporary</td><td>Negligible</td><td>Negligible</td></tr>
<tr><td>Impact of spillages of fuels – AOI 2</td><td>Temporary</td><td>Negligible to minor adverse</td><td>Negligible</td></tr>
<tr><td>Impact of spillages of fuels – AOI 3</td><td>Temporary</td><td>Negligible to minor adverse</td><td>Negligible</td></tr>
<tr><td>Impact of noise on megafauna – AOI 3</td><td>Temporary</td><td>Negligible</td><td>None required.</td><td>Negligible</td></tr>
<tr><td>Impact of noise on fish – AOI 2</td><td>Temporary</td><td>Negligible to minor</td><td>None required.</td><td>Negligible</td></tr>
</table>

Impact	Nature of Impact	Significance	Mitigation/Enhancement Measures	Residual Impact
		adverse		
Impact of noise on fish – AOI 3	Temporary	Negligible	None required.	Negligible
Risk of collision of work vessels with megafauna – AOI 3	Temporary	Negligible	• Visual monitoring of marine mammals (and turtles) by crew so that they can be avoided. This should be conducted on a daily basis and records kept for monitoring purposes. All crew should be vigilant for presence of sensitive species.	No impact
Operation				
Impact of outfall discharges on marine ecology	Permanent	No impact	None required.	No impact
Impact of routine operations in AOI 2 and AOI 3 on marine ecology	Permanent	No impact	None required.	No impact

11.8 References

Abdulqader, E.A.A. (1995) Fisheries and Aspects of Penaeid Shrimps of Bahrain, Ph.D thesis, University of North Wales, Bangor.

Abdulqader et al, 2004

Abdulrahman (1997) A Management Plan for the Viable and Sustainable Development of Tubli Bay, Bahrain. Unpublished.

Al-Ghadban, A.N. and Price, A.R.G. (2002) Dredging and infilling. In: *The Gulf Ecosystem: Health and Sustainability* (Eds. N.Y. Khan, M. Munawar and A.R.G. Price). Backhuys Publishers, Leiden. Pp. 207−217.

Appleby, J.A. and Scarratt, D.J. (1989) *Physical effects of suspended solids on marine and estuarine fish and shellfish, with special reference to ocean dumping: A literature review.* (Canadian Technical report of Fisheries and Aquatic Sciences, No. 1681). Department of Fisheries and Oceans, Halifax, Nova Scotia. 33 pp.

Baldwin, R.M., Gallagher, M.D. and Van Waerebeek, K. 1999. A review of cetaceans from waters off the Arabian Peninsula. In: Oman's Natural History, eds. Fisher, M., Spalton, A. and Gazanfar, S., Backhuys Publishers, Leiden. Pp. 161-189.

Baldwin R.M. 2005. Marine Life of Arabian Seas. SeaWords Publishing, Noordhoek, South Africa. Pp 210.

Bosch, D.T., Dance, S.P., Moolenbeek, R.G. and Oliver, P.G. (1995) *Seashells of Eastern Arabia.* Motivate Publishing, Dubai, United Arab Emirates. 242 pp.

Carpenter, K.E., Krupp, F., Jones, D.A. and Zajonz, U. (1997) FAO species guide for identification purposes. *The living marine resources of Kuwait, Eastern Saudi Arabia, Bahrain, Qatar, and the United Arab Emirates.* Food and Agricultural Organisation (FAO) of the United Nations, Rome. 293 pp.

Dalen, J., and Knutsen, G. M. 1987. Scaring effects in fish and harmful effects on eggs, larvae and fry by offshore seismic explorations. In Merklinger, H.M. (ed.) Progress in Underwater Acoustics. Plenum Publishing Corporation: 93-102.

Dalen, J. og Raknes, A. 1985. Skremmeeffektar på fisk frå 3-dimensjonale seismiske undersøkjingar. Havforskningsinstituttet, rapport nr. FO 8504, Bergen. 22 s.

Everhart, W.H. and Duchrow, R.M. (1970) *Effects of suspended sediments on aquatic environment (Technical Report)* Colorado State University and United States Bureau of Reclamation. 178 pp.

Ghanem, E., Al-Sayed, H. and Abbas, J. (2004). Biological & Sociological Study on Tubli Bay, Bahrain. University of Bahrain.

GEOMATEC, BCSR 2006. Marine Environmental Geographic Information System (MARGIS II). Report submitted to the Government of Bahrain, GEOMATEC, BCSR, August 2006.

Government of South Australia (2012) Underwater Piling Noise Guidelines.

Hiscock, K., Southward, A.J., Tittley, I. and Hawkins, S.J. (2004) Effect of changing temperature on benthic marine life in Britain and Ireland. *Aquatic Conservation* **14**: 333-362.

ITOPF (undated) Effects of Oil Pollution on the Marine Environment (Technical Paper) viewed online May 2016 http://www.itopf.com/fileadmin/data/Documents/TIPS%20TAPS/TIP13EffectsofOilPollutionontheMarineEnvironment.pdf

IUCN (2015) Avicennia marina: accessed online and viewed May 2016 http://www.iucnredlist.org/details/178828/0

Johnston, S.A (1981) Estuarine Dredge and Fill Activities: A Review of Impacts. Environmental Management **5**: 427−440.

Kingdom of Bahrain Supreme Council for Environment EA-8 Guidelines of the Ecological Study Conducted as Part of the EIA Study of Large-Scale Projects involving GIS.

Kinne, O. (1964) The effects of temperature and salinity on marine and brackish water animals. 2. Salinity and temperature salinity combinations. *Oceanography and Marine Biological Annual Review* **2**: 281-339.

McMillan, C. (1984) The distribution of tropical seagrasses with relation to their tolerance of high temperatures. *Aquatic Botany* **19**: 369-379.

Miller, R. L., Bradford, W. L., & Peters, N. E. (1989). Specific Conductance: Theoretical Considerations and Application to Analytical Quality Control. In U.S. Geological Survey Water-Supply Paper. Retrieved from http://pubs.usgs.gov/wsp/2311/report.pdf. Viewed 16/02/15.

Ministry of Municipalities and Agriculture (2007) Bahrain 2030 The National Plan PCMREW, 2006).

O'Hara, J and J.R. Wilcox (1990) Avoidance Responses of Loggerhead Turtles *Caretta caretta* to Low Frequency and Sound. Copeia (1990) **2**:564-567.

Newell, R.C., Seiderer, L.J. and Hitchcock, D.R. (1998) The impact of dredging works in coastal waters: A review of the sensitivity to disturbance and subsequent recovery of biological resources on the seabed. *Oceanography and Marine Biology: an Annual Review* **36**: 127−178.

NOAA (1999) Report - Resources at Risk. Incident Response Documents viewed online May 2016 https://incidentnews.noaa.gov/incident/7405/508404

NOAA (2006) Small diesel spills (NOAA Factsheet). National Oceanographic Atmospheric Administration, Office of Response and Restoration (Emergency Response Division), Seattle Washington.

http://dec.alaska.gov/spar/perp/response/sum_fy10/100111201/NOAAFactsheet_Diesel.pdf (viewed on May 2016).

Nour El-Din, N. M (2004) Impact of cooling water discharge on the benthic and planktonic pelagic fauna along the coastal waters of Qatar (Arabian Gulf). *Egyptian Journal of Aquatic Research*. Vol 30 (A) pp 150-159.

Preen, A. (1989). The Status and Conservation of Dugongs in the Arabian Region. Meteorological and Environmental Protection Administration Coastal Management Series. Report No. 10.

Radhi AK, Al-Saffar N, Mirza F, Abdulla A, Hermis N (1999) Fisheries Census-1998 (boats & fishermen census). Fisheries Statistical Section. Directorate of Fisheries, Ministry of Works & Agriculture, State of Bahrain. 39pp.

Ralph, P.J. (1998) Photosynthetic response of laboratory-cultured Halophila ovalis to thermal stress. Marine Ecology Progress Series **171**: 123-130.

Randall, John, E (1995) The Complete Divers' and Fishermen's Guide to the Coastal Fishes of Oman. Crawford House of Publishing, Bathurst, Australia.

Regional Commission for Fisheries RECOFI (2011) access May 2016 http://www.fao.org/fishery/rfb/recofi/en

Richmond, M.D. (Ed.) (2002) *A Field Guide to the Seashores of Eastern Africa (Second Edition).* Sida/Department for Research Cooperation (SAREC) and University of Dar es Salaam.

Sherk, J.A. and Cronin, L.E. (1971) *Effects of suspended and deposited sediments on estuarine organisms*: *An annotated bibliography of selected references (Contribution No. 443)*.Chesapeake Biological Laboratory, University of Maryland.

SOMER, 2003 'State of the Marine Environment Report. ROPME/GC-11/003.' Regional Organization for the Protection of the Marine Environment, Kuwait. 217 pp.

Southall *et al*. (2007). Marine Mammal Noise Exposure Criteria: Initial Scientific Recommendations. Aquatic Mammals , 33 (4).

Vousden, D.H.P. (1985) Environmental Monitoring and Data Collection as a Marine Conservation Strategy within the State of Bahrain. Proceedings of the ROPME Symposium on Regional Marine Monitoring and Research Programmes. 8-11th December 1985, U.A.E. University, Al-Ain, U.A.E, 39pp.

Vousden, D.H.P. (1988). The Bahrain Marine Habitat Survey: Volume 2. Environmental Protection Committee, State of Bahrain.

Vousden, D.H. (1995) Bahrain Marine Habitats and *Some Environmental Effects on Seagrass Beds.* PhD Thesis, University of Wales, UK. 261 pp.

WoRMS Editorial Board (2014) *World Register of Marine Species.* Available from http://www.marinespecies.org at VLIZ. Accessed March 2016.

12 TERRESTRIAL ECOLOGY AND AVIFAUNA

12.1 Introduction

The majority of the BMP is to be constructed on industrial and brownfield land, but there is a small strip of previously undeveloped land to the south of the Pitch Ponds and Refinery sites which will be utilised as a laydown area and labour camp during the construction phase, See **Section 2.10.2** and **Figure 2.10**. In addition, it is proposed to construct a further laydown area and labour camp to the west of the Alba facility on an area of open desert.

In addition to the construction laydown area associated with the BMP, a new pipe bridge will be constructed within the Ma'ameer Channel to the south of the existing bridge. This area is known to host a number of migratory and non-migratory bird species.

The construction activities have the potential to impact terrestrial ecology and avian interests with regard to both individual species and habitats. The potential impact of the construction phase on the aforementioned receptors has been assessed based upon the sensitivity of the receiving terrestrial habitats and species present. The importance of the impacted habitats on a national scale has also been considered.

12.2 Legislation and Guidance

12.2.1 IFC Performance Standard 6

IFC Performance Standard 6 concerning Biodiversity Conservation and Sustainable Management of Living Natural Resources recognises that protecting and conserving biodiversity, maintaining ecosystem services, and sustainably managing living natural resources are fundamental to sustainable development.

It states that the impact identification process should consider direct and indirect project-related impacts on biodiversity and ecosystem services and identify any significant residual impacts. The project proponent should seek to avoid impacts on biodiversity and ecosystem services, and, where avoidance is not possible, measures to minimise impacts and restore biodiversity and ecosystem services should be implemented.

Where natural habitat is involved, project proponents should retain competent professionals to assist in conducting the risks and impact identification process. If critical habitat is involved, external experts with appropriate regional experience should be retained to develop a mitigation hierarchy.

12.2.2 Convention on Biological Diversity

The Protocol Concerning the Conservation of Biological Diversity and the Establishment of Protected Areas (2002) aims to preserve environmental systems and wildlife, especially endangered species and those that migrate through the territorial waters. Bahrain signed in 1992 and subsequently ratified in 1996.

12.2.3 Ramsar Convention on Wetlands, 1975

In Bahrain, this international treaty was ratified by Royal Decree No. 3 on the 26th February 1997. The nomination of two Ramsar 'Wetlands of International Importance' followed on the 27th October 1997, namely:

- *The Hawar Islands* – this island archipelago, situated approximately 20 km off the south-east coast of Bahrain, was primarily designated owing to the fact it comprises undisturbed marine and coastal habitats which provide sanctuary for numerous species of breeding seabirds, a significant proportion of which are either threatened, rare or endangered.
- *Tubli Bay* – This enclosed water body, located in the north-east of Bahrain, supports the largest area of mangroves in Bahrain. One type of mangrove exists which is the Black Mangrove; *Avicennia marina*. The area is one of the main sites for migratory and breeding waterbirds in the country. The mangroves are also an important nursery ground for the commercially important Green Tiger Prawn (or shrimp) *Penaeus semisulcatus*, as well as certain marine fishes.

12.2.4 Important Bird Areas

There are four Important Bird Areas (IBAs) in Bahrain as designated by BirdLife International, a global partnership of conservation organisations which aim to conserve avifauna, their habitats and global biodiversity. These are: Tubli Bay, Hawar Islands, Maqabah and the South West Coast.

12.2.5 Wildlife and Natural Habitat Convention GCC

Convention on the Conservation of Wildlife and Natural Habitats in GCC Countries (2003) focuses on the conservation of ecosystems and wildlife, especially those species at risk from extinction, and aims to raise the standards of conservation of flora, fauna and natural habitats.

12.2.6 Legislative Decree No. 21 of 1996, Kingdom of Bahrain

Legislative Decree No. 21 of 1996 with Respect to the Environment aims to protect the environment from polluting sources and factors, and put an end to its deterioration by drawing up the required plans and policies to preserve it from the harmful effects resulting from activities causing damage to human health, agricultural crops, marine life, wildlife, other natural resources and the climate. Article 6 states "It shall not be permitted for any person or project to use the environment in any environment polluting activity, contributing to its deterioration activity, causing damage to the natural resources, living beings, breach, prevent the utilisation, use and the proper and reasonable exploitation of the environment". The law allows the designation of protected areas which must not be utilised by any person or project.

12.3 Assessment Methodology

The existing Refinery, Sitra Tank Farm and Sitra Wharf do not have any areas of terrestrial ecological interest and hence are excluded from this assessment. There will be no direct impacts on any protected or designated areas, such as Tubli Bay.

During the scoping study, one area of interest for the parameter of terrestrial ecology was identified, namely the coastal strip south of the BMP site. Following further evaluation of the study area, review of information provided by the BMP project and discussions with the SCE, two additional areas were identified: the land to the west of Alba and the Ma'ameer Channel. These are shown on **Figure 12.1**.

A qualitative walkover survey of the coastal strip was undertaken on 26th January 2016 and the Ma'ameer Channel was surveyed on 15th February 2016, both by Dr Saeed Abdulla Al Khuzai. As requested by the SCE, the focus of the survey within the Ma'ameer Channel was on the birds present particularly on and around the small islets - three to the north of the pipe bridge and one to the south (**Figure 12.1**). The area to the west of Alba was subjected to a walkover survey on 9th March 2016. The surveys were undertaken during the winter months when migratory birds visit the Kingdom and when desert plants are more abundant due to increased rainfall and a decrease in temperatures. Hence, the survey provided the best indication of the species and habitats present in the areas of interest.

A general overview of the sites was taken and all special features were identified. All encountered plants and animals were recorded. The status of individual plant and animal species was noted for Bahrain and the Region.

The significance of the impact of the BMP construction and operation on terrestrial ecology and avifauna has been assessed by determining the sensitivity of habitats and species and expected level of disturbance.

Each habitat and floral and faunal species (also classified as a receptor) can be identified as having either local (e.g. habitat uncommon in surrounding area), national (e.g. habitat rare in Bahrain) or international value (e.g. species also rare in other parts of the world). This value relates to that receptor's sensitivity. The sensitivity of an ecological receptor is based on its reliance on the surrounding area/habitat and its ability to adapt. The sensitivity and magnitude criteria for habitats and floral and faunal species (including avifauna) in Bahrain that have been used to classify the significance of the predicted environmental impacts are presented in **Table 12.1**. To calculate the level of significance, **Table 12.2** has been used.

Table 12.1 Sensitivity of Terrestrial Ecological Receptors and Magnitude of Impact

Impact	Sensitivity (vulnerability of receptor to change)	Magnitude (size, extent and duration of impact)
High	Habitat/species of particularly rare nature (nationally or internationally important, e.g. Ramsar Site, on the IUCN Red List, IBA BirdLife International), susceptible to relatively small changes. Species which are highly selective and limited to select habitats.	Noticeable change in habitat composition over an extensive area, impacting the survival of species. A very intensive change over a more limited area. High levels of frequent disturbance resulting in species abandoning the site.
Medium	Habitat/species of moderate value classified as locally rare or limited populations.	Moderate changes in localised area. Moderate disturbance resulting in some short term impacts.

Impact	Sensitivity (vulnerability of receptor to change)	Magnitude (size, extent and duration of impact)
Low	A relatively common habitat/species, frequently seen across the whole country.	Slight change in any components. Some short term low level disturbance.
None	A very common habitat or species.	Virtually imperceptible change in floral composition. Very low levels of disturbance.

Table 12.2 Impact Classifications

		Sensitivity			
		Not sensitive	**Low**	**Medium**	**High**
Magnitude	**High**	Negligible	Moderate	Major	Major
	Medium	Negligible	Minor	Moderate	Major
	Low	Negligible	Minor	Minor	Moderate
	None	Negligible	Negligible	Negligible	Negligible

Title: Survey Area - Terrestrial Ecology		Client: Bapco Technip
Project: Bapco Modernization Program		
Date: May 2016	Figure No.: 12.1	Consultant: Environment Arabia
Datum: WGS 84 - UTM 39N	Scale: 1:35,000 (A4)	

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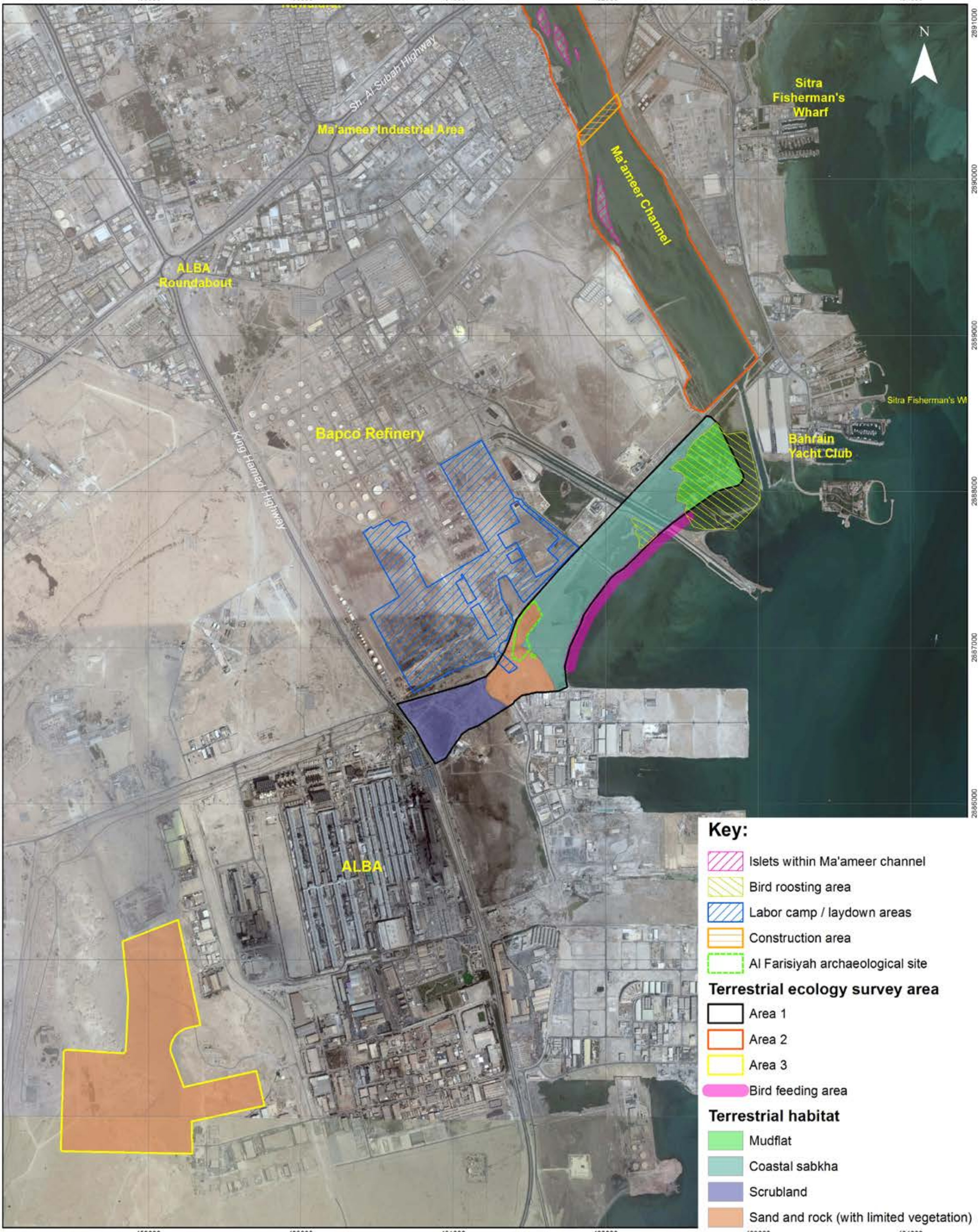
12.4 Baseline

12.4.1 Coastal Zone South of BMP Site (Plot for Construction Laydown Area/Labour Camp)

12.4.1.1 General

A habitat map for the three areas surveyed is provided in **Figure 12.2**. Sabkha habitat was observed within the site, with damp and salt-encrusted soil (**Figure 12.3**). In the western side of the site, patches of low bushes such as *Sueda sp.* with a few trees such as Mesquite (*Prosopis juliflora* and *Tamarix sp.* were observed (**Figure 12.4**). Near the coast and towards the east, more saltmarsh plants such as *Halocnemum* and *Sueda* were observed, with small, shallow water bodies present during high tide where many seabirds were observed (**Figure 12.4**).

The area contains a large amount of waterborne rubbish such as plastic and wood as can be seen in **Figure 12.3**, but despite this, the coastal area attracts a large amount of seabirds. Furthermore, there were a few patches of *Phragmites* reeds and *Juncus* recorded in some depressions near the Bapco intake channels.



Title: Terrestrial Habitat Map		Client:
Project: Bapco Modernization Program		
Date: May 2016	Figure No.: 12.2	Consultant:
Datum: WGS 84 - UTM 39N	Scale: 1:22,000 (A4)	

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Figure 12.3 Coastal Sabkha with Halophytic Plants

12.4.1.2 Flora

Halophytic plants are the dominant flora in the area, with the main shrub observed being *Sueda vermiculata*. Considering the whole site, plant cover was low, but there are areas of high species cover in the middle of the site and towards the west. Eleven species of plant were identified, two of which were trees. **Table 12.3** presents the common name, scientific name and the status in Bahrain and the region, and some examples of the species found are provided in **Figure 12.5**.

Table 12.3 List of Plant Species and Their Status (Phillips, 1988)

Scientific Name	Common Name	Status in Bahrain	Status in the Region
Sueda vermiculata	Suwaid	Common perennial	Common
Alhagi maurorum	Camel thorn	Common perennial	Very common
Tetraena (Zygophyllum) qatarensis	Bean caper	Common perennial	Very common
Lycium shawii	Desert thorn	Common shrub	Common
Phragmites australis	Reeds	Common perennial	Very common
Juncus rigidus	Hard sea rush	Used to be common (no current data)	Common
Malva parviflora	Mallow	Common annual	Common
Halocnemum sp.	Jointed glasswort	Common perennial	Common
Lycium shawii	Desert thorn	Common shrub	Common
Tamarix sp.	Tamarisk	Common tree	Common
Prosopis juliflora	Mesquite	Naturalized	Common

Figure 12.4 Existing Conditions

1 - *Prosopis juliflora* and *Sueda vermiculata.* 2 - *Halocnemum sp.* 3 - Sea gulls roosting (mostly black-headed gulls).

19.4.1.3 Fauna

A few individuals of lizard belonging to *Acanthodactylus sp*. were spotted near the shoreline, and many individuals of the Darkling Beetle (Walker & Pittaway, 1987) were observed in the centre of the site where the shrubs were present.

19.4.1.3 Avifauna

Sea birds were the main group present within the study area. A large flock of flamingos (more than 120 individuals) was observed feeding in the shallow water along the coastline, and hundreds of seagulls were roosting in the far eastern part of the surveyed area. In addition, birds were observed roosting to the immediate west of the Bapco intake. 23 Western Reef Heron, 27 Grey Heron and 20 Common Cormorants were counted. The shallow water along the coastline is an important bird feeding and roosting area.

Table 12.4 lists the bird species observed together with their status in Bahrain and the region, and **Figure 12.5** presents some examples of the birds observed. The area is host to many migratory bird species, and although the birds are common, the habitat available for over-wintering birds in Bahrain is in decline due to on-going reclamation activities in coastal areas. The site is, therefore, classified as of medium sensitivity.

Table 12.4 List of Birds and Their Status

Scientific Name	Common Name	Status in Bahrain	Status in the Region
Phoenicopterus roseus	Greater Flamingo	Migratory/common	Common
Egretta gularis	Western reef Heron	Resident breeder/ common	Common
Ardea cinerea	Grey Heron	Migratory/common	Common
Larus barabensis	Baraba Gull	Migratory/common	Very common
Larus ridibundus	Black-headed Gull	Migratory/common	Very common
Chroicocephalus genei	Slender-billed Gull	Migratory/common	Common
Phalacrocorax carbo	Great Cormorant	Migratory/common	Very common
Hydroprogne caspia	Caspian Tern	Migratory/breeding	Common
Streptopelia decaocto	Collared Dove	Resident breeder/ v. common	Very common
Galerida cristata	Crested Lark	Resident breeder/ v. common	Very common
Passer domesticus	House Sparrow	Resident breeder/ v. common	Very common

Figure 12.5 Examples of Identified Plant Species

Prosopis juliflora

Tamarix sp.

Phragmites australis

Juncus rigidus

Lycium shawii

Tetraena (Zygophyllum) qatarensis

Alhagi maurorum

Malva parviflora

Figure 12.6 Examples of Birds Observed

Greater Flamingos

Baraba Gull

Adult Great Cormorant

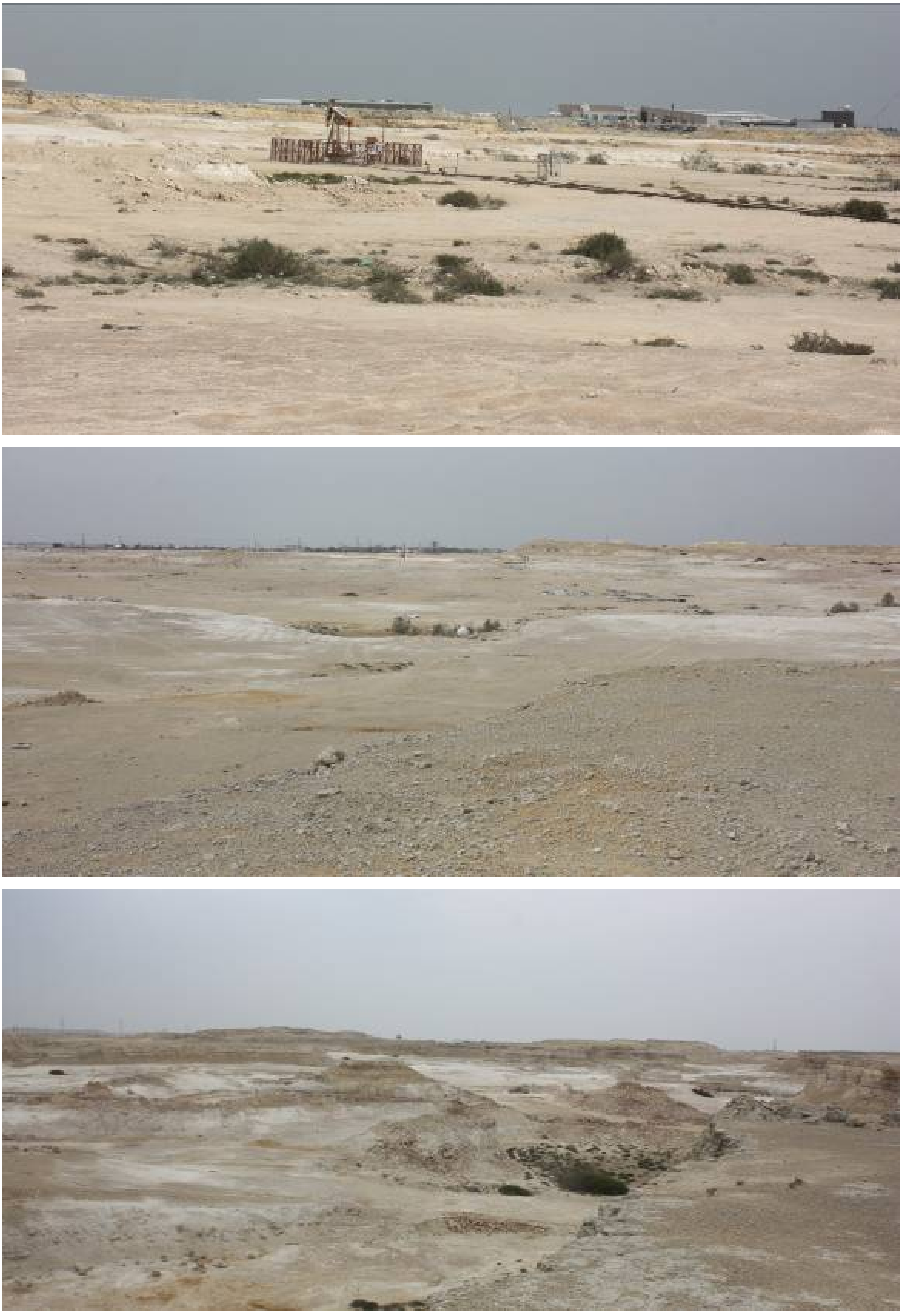
Roost of Reef and Grey Herons

12.4.2 Labour Camp Area to West of Alba

The proposed labour camp will extend over an area of approximately 90 hectares. The site is of very low sensitivity from an ecological perspective; very few plant specimens were found and the site is mostly sand and rock. The site is within the Awali Oil and Gas Field and as such there is infrastructure associated with the oil and gas industry, e.g. pipelines, oil wells and sumps.

Towards the south west corner of the site, there is a camel farm and several camp sites. Camping is permitted in Bahrain's desert between October and March in certain designated zones. **Figure 12.7** shows some views across the site.

Figure 12.7 Views Across Proposed Labour Camp Site to West of Alba



12.4.3 Ma'ameer Channel

The Ma'ameer Channel, with its shallow water, represents a suitable feeding ground for many wintering seabirds and shorebirds. For more than four decades, the habitation of the Ma'ameer Channel and Tubli Bay by many waterfowl has been documented (BNHS 1987, Saleh and Mohamed 1990, Mohamed 1991 & 1998).

To the north of the existing pipe bridge there are three small islets, the southern tip of the lower islet is approximately 350 m from the bridge (**Figure 12.8**). To the south of the pipe bridge, there is a further islet approximately 300 m from the bridge (**Figure 12.9**).

Figure 12.8 Northern Islets

Figure 12.9 Southern Islet

Black mangrove trees (*Avicennia marina*) were found on all islets and along the shoreline of Ma'ameer channel. The shallow water in the channel attracts large numbers of over-wintering seabirds such as Greater flamingos, herons and gulls. Hundreds of flamingos, tens of western reef herons were observed feeding around the islets. Gulls were also observed roosting on the islets (see inset).

Although there is no documentation regarding breeding on the islets, it is possible that in the spring and summer (from April to August), some species may use the shore and mangroves to breed. Birds such as black winged stilt, moor hen, kentish plover regularly breed in the Sanad mangrove within Tubli Bay. **Table 12.5** provides a list of the birds observed during the survey together with their status in Bahrain.

Table 12.5 List and Status of Birds Recorded in Ma'ameer Channel

Species Name	Status in Bahrain
Great Cormorant *Phalocrocorax carbo*	Common migrant, WV, PM
Greater Flamingo *Phoenicopterus roseus*	Common migrant, WV
Slender-billed Gull *Chroicocephalus genei*	Common migrant, WV
Baraba Gull *Larus barabensis*	Common migrant, PM, WV
Black-headed Gull *Larus ridibundus*	Common migrant, WV
Black-winged Stilt *Himantopus himantopus*	Common, RB
Western Reef Heron *Egretta gularis*	Common, RB
Grey Heron *Ardea cinerea*	Common migrant, PM
Redshank *Tringa totanus*	Common migrant, PM, WV
Notes: PM: Passage Migrant, WV Winter Visitor, RB Resident Breeder	

As the three northern islets are not far from Shaikh Jaber Highway, traffic noise is discernible. There is a public walkway running along the shoreline close to the islets and a children's park. The presence of the birds indicates that they are undisturbed by the present level of noise. **Figure 12.10** provides images of the surrounding land use.

Figure 12.10 Land Use Around Ma'ameer Channel Islets

12.5 Assessment of Impacts

12.5.1 Coastal Zone South of BMP Site

In an international context, the need to secure and conserve important feeding sites along the migration routes of waders staging through the Gulf region has been highlighted by the IUCN and Birdlife International (Middle East). Each Gulf nation has been encouraged to identify key sites within its territory and to manage these staging posts sympathetically.

Figure 12.11 shows the extent of the construction laydown area superimposed on the habitat map for the coastal strip.

Title: **Comparison of Construction Laydown Areas and Terrestrial Habitat**		Client: Bapco Technip
Project: Bapco Modernization Program		
Date: May 2016	Figure No.: 12.11	Consultant: Environment Arabia
Datum: WGS 84 - UTM 39N	Scale: 1:22,000 (A4)	

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Due to the importance of the site for migratory, roosting and feeding birds, the construction laydown area has been designed to avoid the mudflats in the eastern part of the surveyed area and to the immediate west of Bapco's intake, and the coastal fringe. A coastal buffer zone has also been created to minimise disturbance to birds. It is predicted that there may be a temporary minor adverse impact on birds' activities during mobilisation of the construction laydown area; however, the birds should still populate the area once the site has been established. The birds are currently subjected to disturbance due to the presence of the 'Alba' haul road and Bapco's operational activities in the low level pump house and intake channels.

The loss of the sand and rock habitat and scrubland in the western part of the surveyed area would have a negligible impact, as this type of habitat is common in Bahrain and it would be a temporary loss during the construction phase. Once construction is finished and the site demobilised, the habitat will gradually recover.

The predicted noise level from the BMP at the coastal strip during operation is 54 dB. This is similar to the daytime noise levels recorded during the baseline noise survey at site N5 which is at the far western end of the coastal strip. The noise level at site N5 averaged out at 52.6 LA_{eq} dB. This is predicted to have a minor adverse impact on birds during operation of the BMP.

12.5.2 Labour Camp Area to West of Alba

The loss of the sand and rock habitat within the proposed labour camp to the west of Alba would have a negligible impact on terrestrial ecology as this habitat is of low sensitivity. The identified plant species are very common in Bahrain.

12.5.3 Ma'ameer Channel

As discussed in **Section 12.4.3**, the Ma'ameer Channel, with its shallow water, represents a suitable feeding ground for many wintering seabirds and shorebirds. During the baseline survey, birds were observed feeding in the shallow water of the channel, roosting on the islets and the shoreline. The site is important as a wintering site and, based on current evidence, is not documented as a breeding site.

As part of the BMP, a new pipe bridge will be constructed to the immediate south of the existing bridge and the existing bridge would be dismantled. The islets within the Channel would not be physically disturbed. There is no impact for habitat loss.

The northern islets are approximately 400m from the new pipe crossing and the southern islet is approximately 300m away. The northern islets are currently subjected to disturbance due to the proximity of Shaikh Jaber Highway and Ma'ameer Village. At the time of the site visit, work was being conducted on the pipe bridge which did not seem to have an impact on the birds present. Although the new pipe bridge will probably generate higher levels of noise than the work currently being undertaken, this is an indication that the birds will still populate the area during construction. However, it is predicted that there will be a temporary minor adverse impact on birds during construction of the pipe bridge.

12.6 Mitigation

The BMP design has already considered the potential impact of the location of the construction compounds on the coastal fringe ecology and the design has already been altered to relocate the compounds away from the coastal fringe to minimise their impact. However, to minimise any potential impacts on terrestrial ecology the construction compound should be securely fenced and workers should not be allowed to wander outside the fenced area. Good housekeeping and waste management is required to ensure that waste is not blown into the coastal and marine environment. No discharges of wastewater should be permitted to the marine environment. All equipment should be stored within the fenced area to reduce the impact on terrestrial habitat, and all vehicles should stick to the allocated access routes.

Within the Ma'ameer Channel, the construction compound should be carefully sited to avoid damage to the shoreline habitat and islets. A 'soft start' should be considered for pile driving to reduce piling noise. To practice the soft start method, a pile is initially driven with low hammer energy. As the pile is driven further into the soil, the hammer energy is increased as necessary. The soft start is intended to be a warning mechanism for fauna so that they can vacate the area.

It is predicted that operational noise will have a minor adverse impact on feeding and roosting birds at the coastal fringe. It is possible, but not certain, that during the EPC phase BMP noise emissions will be further reduced at source or otherwise mitigated.

12.7 Monitoring

Adherence to the mitigation measures should be checked as part of the regular environmental audit for the construction phase.

12.8 Summary

Table 12.6 provides a summary of impacts for terrestrial ecology and avifauna.

12.9 References

Birds were identified and listed according to the following:

- Bahrain Systematic List (2006) Bahrain Bird Report. http://www.hawar-islands.com
- Bird check list of Bahrain: http://avibase.bsc-eoc.org/checklist.jsp?region=BH
- Gulls in Bahrain: http://www.gull-research.org/indexelements/bahrain.htm
- http://avibase.bsc-eoc.org/checklist.jsp?region=BH
- http://www.gull-research.org/indexelements/bahrain.htm

Phillips, D. C. (1988). Wild Flowers of Bahrain, A field guide to herbs, shrubs and trees.

Walker, D. H. and Pittaway, A. R. (1987). Insects of Eastern Arabia.

Table 12.6 Summary of Terrestrial Ecology Impacts

Impact	Nature of Impact	Significance	Mitigation/Enhancement Measures	Residual Impact
Construction				
Loss of feeding and roosting grounds for birds during construction - coastal fringe	Temporary	Minor adverse	• Design mitigation has considered the layout of the construction compound to avoid sensitive areas.	Minor adverse
Loss of terrestrial habitat - coastal fringe	Temporary	Negligible	• Ensure construction compound is securely fenced. • Good housekeeping and waste management to avoid windblown litter. • No discharge of wastewater to the marine environment. • Store all equipment within fence-line. • Vehicles to adhere to allocated access roads. • No workers to be permitted outside the fence-line.	Negligible
Loss of terrestrial habitat - site west of Alba	Temporary	Negligible	None required.	Negligible
Disturbance to feeding and roosting grounds for birds during construction - Ma'ameer Channel	Temporary	Minor adverse	• Consider 'soft start' for piling activities.	Minor adverse
Loss of terrestrial habitat - Ma'ameer Channel	Temporary	Negligible	None required.	Negligible
Operation				
Impact of operational noise on feeding and roosting birds – coastal fringe	Permanent	Minor Adverse	Measures to reduce noise emissions from BMP plant will be considered further during the EPC phase.	Minor Adverse

13 CULTURAL HERITAGE AND ARCHAEOLOGY

13.1 Introduction

Bahrain is a thriving multi-cultural hub which welcomes people from all around the world. Manama is the capital of Bahrain and also its largest city. Manama enjoys a distinct reputation as a tourism and cultural hub regionally and internationally, as shown by its selection as the Capital of Arab Culture in 2012, Capital of Arab Tourism in 2013, and Capital of Asian Tourism in 2014.

The earliest human settlement in Bahrain dates back almost 4,000 years. Since then it has been inhabited by a series of different civilizations, starting with Dilmun, then Tylos, and finally the Islamic period. Therefore, Bahrain is rich in historical assets, with an assemblage of archaeological remains (both inland and offshore), historic monuments and areas of historic urban character. There have been archaeological excavations at a number of sites around the Kingdom, providing information on the nation’s historic development and chronological framework; revealing the culture and the historic importance of Bahrain as a trading point in the Gulf.

This chapter considers the potential impacts of the proposed BMP on Bahrain's sites of cultural heritage and archaeological importance.

13.2 Legislation and Guidance

13.2.1 International

The IFC's Performance Standard No. 8 concerns cultural heritage. This states that, in addition to complying with the applicable law on the protection of cultural heritage, including national law implementing the host country's obligations under the Convention Concerning the Protection of the World Cultural and Natural Heritage, the project proponent should identify and protect cultural heritage by ensuring that internationally recognised practices for the protection, field-based study, and documentation of cultural heritage are implemented.

It states that where there is the potential to impact cultural heritage, the project proponent should retain competent professionals to assist in the identification and protection of cultural heritage. The siting and design of the project should avoid significant impacts to cultural heritage. There should be procedures in place for dealing with chance finds. Chance finds should not be disturbed until an assessment by competent professionals is made.

Where a project may affect cultural heritage, the client should consult with Affected Communities. Consultation should also involve the relevant national or local regulatory agencies that are entrusted with the protection of cultural heritage.

The Performance Standard provides requirements for three types of cultural heritage: replicable, non-replicable and critical.

13.2.1.1 Removal of Replicable Cultural Heritage

Where the client has encountered tangible cultural heritage that is replicable and not critical, the client should apply mitigation measures that favour avoidance. Where avoidance is not feasible, the client should apply a mitigation hierarchy as follows:

- Minimise adverse impacts and implement restoration measures, in situ, that ensure maintenance of the value and functionality of the cultural heritage, including maintaining or restoring any ecosystem processes needed to support it;
- Where restoration *in-situ* is not possible, restore the functionality of the cultural heritage, in a different location, including the ecosystem processes needed to support it;
- The permanent removal of historical and archaeological artifacts and structures is undertaken in line with internationally recognised practices and by competent professionals; and
- Only where minimisation of adverse impacts and restoration to ensure maintenance of the value and functionality of the cultural heritage are demonstrably not feasible, and where the Affected Communities are using the tangible cultural heritage for long-standing cultural purposes, compensate for loss of that tangible cultural heritage.

13.2.1.2 Removal of Non-Replicable Cultural Heritage

The client should not remove any non-replicable cultural heritage unless all of the following conditions are met:

- There are no technically or financially feasible alternatives to removal;
- The overall benefits of the project conclusively outweigh the anticipated cultural heritage loss from removal; and
- Any removal of cultural heritage is conducted using the best available techniques.

13.2.1.3 Critical Cultural Heritage

Critical cultural heritage consists of one or both of the following types of cultural heritage: i) the internationally recognised heritage of communities who use, or have used within living memory the cultural heritage for long-standing cultural purposes; or ii) legally protected cultural heritage areas, including those proposed by host governments for such designation.

The client should not remove, significantly alter, or damage critical cultural heritage. In exceptional circumstances when impacts on critical cultural heritage are unavoidable, the client will use a process of Informed Consultation and Participation of the Affected Communities which uses a good faith negotiation process that results in a documented outcome. The client should retain external experts to assist in the assessment and protection of cultural heritage.

Legally protected cultural heritage areas are important for the protection and conservation of cultural heritage, and additional measures are needed for any projects that would be permitted under the applicable national law in these areas. In circumstances where a proposed project is located within a legally protected area or a legally defined buffer zone, the client, in addition to the requirements for critical cultural heritage cited above, should meet the following requirements:

- Comply with defined national or local cultural heritage regulations or the protected area management plans;
- Consult the protected area sponsors and managers, local communities and other key stakeholders on the proposed project; and
- Implement additional programs, as appropriate, to promote and enhance the conservation aims of the protected area.

13.2.2 National

The basis of heritage management and legislation in Bahrain lies within international policy and is underpinned by its international agreements. Bahrain joined UNESCO in 1972 and ratified the World Heritage Convention in 1991. The Convention defined the kind of natural or cultural sites that can be considered for the World Heritage list. It sets out the duties of state parties in identifying potential sites and their role in protecting and preserving them. By signing the Convention, each country pledges to conserve not only World Heritage sites situated in its territory, but also to protect its natural heritage. The state parties are encouraged to integrate the protection of cultural and natural heritage into planning programs, set up staff and services at their sites, undertake scientific and technical conservation research and adopt measures which give this heritage a function in the day-to-day life of the community.

In relation to the Convention, in 1995 Bahrain published Royal Decree No. 11 Concerning the Protection of Antiquities. This is known locally as the 'Heritage Law' and includes measures to protect some elements of heritage and archaeological assets.

The Bahrain Authority for Culture and Antiquities (BACA) is the institution in charge of archaeology and cultural heritage (it was formerly the Ministry of Culture). It is composed of three directorates: culture & arts, museums and archaeology & heritage.

13.3 Assessment Methodology

A semi-quantitative approach has been adopted for the assessment of cultural heritage and archaeological impacts of the BMP, based on review of secondary data and a walkover survey by representatives from the BACA with EACS and Bapco.

According to the contemporary legal regulations and standards of the Kingdom of Bahrain, no formalized method for the assessment of impacts on the cultural heritage and archaeology has been stipulated. However, recognition of the importance of cultural heritage assets is growing, as they form part of the fabric that makes Bahrain an attractive location for living and working in the Gulf Region. The National Register of cultural heritage and antiquities is steadily growing, and excavations continuously discover new archaeological treasures. The sensitivity and magnitude criteria that will be used for the assessment for cultural heritage and archaeology are presented in **Table13.1**.

Table 13.1 Cultural Heritage and Archaeological Sensitivity in Bahrain

Level of Impact	**Cultural Heritage Sensitivity**		**Magnitude**
	Significance **(importance in international and national frameworks)**	**Vulnerability** **(State of conservation of the material components)**	**(size, extent and duration of impact anticipated)**
High	Cultural feature or archaeological artifact constitutes or is part of a site of international importance (e.g. designated or proposed as a UNESCO World Heritage Site or listed by World Monuments Fund).	The historic fabric of the cultural feature or artefact is highly endangered in result of its critical level of disintegration or physical instability.	Permanent loss / destruction of cultural feature or archaeological artefact (with no records made).
Medium	Cultural feature or archaeological artifact constitutes or is part of a site of national importance (i.e. entry on National Heritage Register).	The historic fabric of the cultural feature or artefact is endangered in result of its tendency towards instability, neglected state of conservation, treatment with inappropriate methods and substances or damages resulting from earlier developments.	Permanent loss / destruction of cultural feature or archaeological artefact (with records made). Permanent sterilisation, e.g. leaving cultural feature or archaeological artefact *in situ* but removing access to them. Displacement of cultural heritage (evacuation from site towards alternative location) Permanent change in adjoining land use that reduces / enhances the contextual value of the area with reference to the cultural features or archaeological artefacts.
Low	Cultural feature or archaeological artifact constitutes or is part of a site of local importance and is attributed significance in publications or by the local community. This heritage is often in the process of being prepared for national register listing.	The physical structure of these heritage resources appears acceptable but is weakened by natural processes of material disintegration throughout time. Conservation measures may be required for further stabilization.	Temporary loss of access to or loss of interpretative facilities of cultural features or archaeological artefacts. Temporary change in adjoining land use that reduces / enhances the contextual value of the area with reference to the cultural feature or archaeological artefact. Loss of parts which constitute minor aspects of the heritage resource (with records made).
Not sensitive	Historic structure of negligible importance.	Cultural heritage which recently underwent conservation treatment and is considered insensitive to adjacent activities.	No discernible loss or displacement of cultural feature or archaeological artefact. Permanent or temporary change in adjoining land use that makes no discernible reduction / enhancement to the contextual value of the area with reference to the cultural feature or archaeological artefact.

To calculate the level of significance, **Table 13.2** has been used.

Table 13.2 Impact Classifications - Cultural Heritage and Archaeology

		Sensitivity			
		Not sensitive	**Low**	**Medium**	**High**
Magnitude	**High**	Negligible	Moderate	Major	Major
	Medium	Negligible	Minor	Moderate	Major
	Low	Negligible	Minor	Minor	Moderate
	Not sensitive	Negligible	Negligible	Negligible	Negligible

13.4 Baseline

A review of secondary data during the Environmental Scoping Phase revealed the presence of a cemetery on the southern boundary of the BMP site and three archaeological sites noted during a survey by a French expedition team in the 1980s. (**Figure 13.2**).

These sites were visited by archaeologists from BACA on 12th January 2016. A full report of the site visit was provided by Dr Pierre Lombard and is contained in **Appendix 13A**.

The cemetery was encountered during the construction of the Low Sulphur Diesel Plant by Bapco. Following consultation with BACA, Bapco fenced the site with a simple post and chain fence to ensure its preservation. The BACA noted that it is associated with the ancient village of Al Farisiyah dating back to the 16th/17th century, and is largely covered with aeolian sand with many graves and gravestones clearly visible (**Figure 13.1**).

Figure 13.1 Cemetery Associated with Al Farisiyah Village

Title: Location of Sites of Archaeological Interest

Project: Bapco Modernization Program

Date: June 2016

Figure No.: 13.2

Datum: WGS 84 - UTM 39 N

Scale: 1:15,000 (A4)

Client: Bapco Technip

Consultant: Environment Arabia

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The three archaeological sites noted during scoping, were surveyed in 1986 by the French Archaeological Mission in Bahrain during the preparation of the Bahrain Archaeological Map. They are registered in this database as Nos. 191, 192 and 193. The descriptions given in the database are as follows:

Site 191: Small ruined mosque on a flat area, lines of walls visible with small pieces of bed rock; two or three pillars visible inside of the musalla. N-S trench in the middle of the musalla, and pieces of broken concrete slabs. Sea to the East, marshes to the north, rock-sandy area to the south and west. Could be connected with site 192 & 193, an abandoned settlement not far north.

Site 192: Big waste area between the Refinery and the sea; electrical lines; marshes. Many small ruins : old abandoned village. No walls standing but lines of small pieces of bed-rock; lot of ashed and black powder on the surface. Could be houses built in barasti on stone bases; some places covered by small shells. Connected with site 193, and maybe with 190 and 191 further south. On the aerial map (1986), many traces between all these sites, probably old gardens.

Site 193: Small elevation with a ruined mosque on top : small lines of fragments of bed-rock; no mihrab visible; two rooms with small terrace outside, at a lower level. Big built pool, approximately round, at the south western corner, with small canal or wadi. Graveyard indicated on the map to the west of the mosque.

The BACA has reported that the description of these sites is in accordance with local historical tradition, which situated a village in this area; Al Farisiyah. This village was destroyed and relocated elsewhere in circa 1920. Photos from the site visit of these sites are presented in **Figure 13.3**.

Figure 13.3 Sites Associated with Al Farisiyah Village from French Survey 1986

Top Left: Site 191
Top Right: Site 192
Bottom Left: Site 193

13.5 Impact Assessment

13.5.1 Construction Phase

There will be no direct impact on the identified sites of archaeological significance from the construction of the new Refinery units associated with the BMP, as all the new units will be located within the existing boundary of the Refinery and the pitch ponds site. There would be no impact on the cemetery as this is already identified as an Exclusion Zone on the project plans.

There is the potential to impact the identified sites of archaeological significance during the construction phase due to the need to provide laydown areas and labour camps. Given the importance of the sites on a national level as described by the BACA, the magnitude of impact and the sensitivity of the sites would be medium and their destruction could lead to a moderate adverse impact. The BACA has requested fencing for two areas of interest (**Appendix 13A**).

The construction laydown areas and labour camps have been designed to avoid the areas of interest which will be fenced prior to the start of the mobilisation period in line with the request from the BACA (**Figure 13.4**). There would, therefore, be a negligible impact on sites of archaeological significance during the construction phase.

13.5.2 Operation Phase

The sites of archaeological significance are outside the development footprint and therefore, once operational, there would be no impacts on sites of archaeological significance.

13.6 Mitigation

Mitigation measures for the protection of features/sites of archaeological significance have been included in the project's design, i.e. design mitigation. As described above, the areas of archaeological significance will be fenced prior to the start of mobilisation. No further mitigation measures are required.

13.7 Monitoring

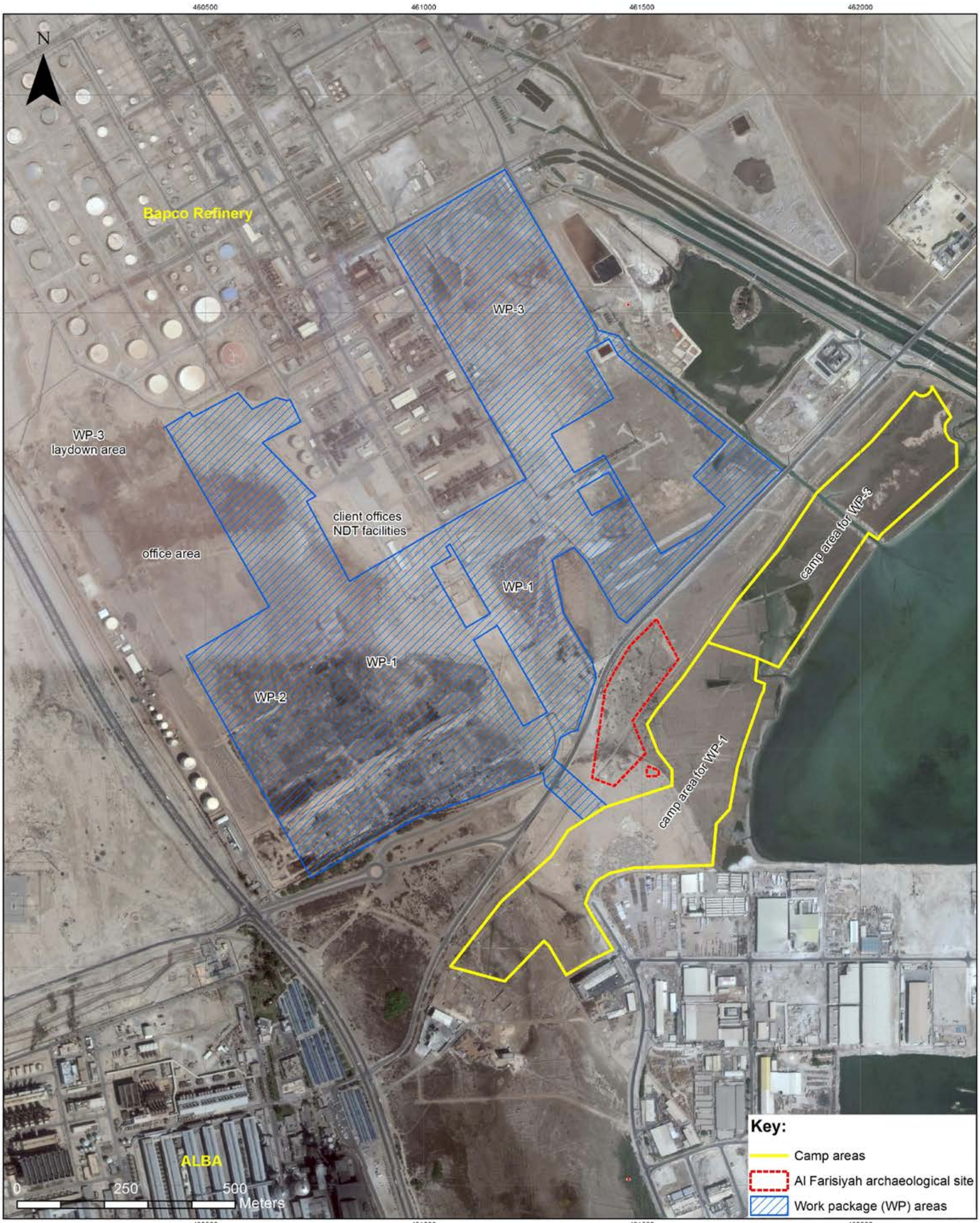
During construction, checks should be made to ensure that the fencing surrounding the areas of archaeological interest is intact and that access is prohibited. During site preparation and earth-moving activities in the mobilisation phase, should any archaeology be discovered, work should stop and the BACA should be contacted immediately.

13.8 Summary

A summary of the predicted impacts for the parameter of cultural heritage and archaeology is provided in **Table 13.3**.

Table 13.3 Summary of Cultural Heritage and Archaeology Impacts

Impact	Significance	Mitigation/Enhancement Measures	Residual Impact
Impact during construction on sites of archaeological significance	Negligible	Design mitigation includes protection of areas of interest by providing fencing prior to mobilisation.	Negligible
Impact of operation phase	Negligible	The sites should continue to be fenced off.	Negligible



Title: **Archaeological Areas to be Fenced**		Client: Bapco / Technip
Project: Bapco Modernization Program		
Date: June 2016	Figure No.: 13.4	Consultant: Environment Arabia
Datum: WGS 84 - UTM 39N	Scale: 1:8,000 (A4)	

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14 TRAFFIC AND ACCESS

14.1 Introduction

The BMP will require a significant number of vehicle movements during construction to transport materials, equipment and the workforce. It is estimated that up to 15,000 construction workers will be required. These workers will need to be transported to and from site at the beginning and end of each shift. Construction materials and equipment will also need to be brought to site; this will include a number of oversized loads. During operations there will be a requirement for a larger workforce (around 600 additional staff) and an increase in the quantity of supplies bought to site.

Whilst the Bapco Refinery and BMP are located on an established main road network there remains the potential for traffic and access impacts due to the scale of the project, particularly during the construction phase.

This section describes the expected type and quantity of traffic movements associated with the BMP and the potential impacts on the local road network. It also identifies the mitigation measures to minimize traffic impacts.

14.2 Legislation and Guidance

The only directly relevant legislation or guidance identified are the World Bank Group General Environmental Health and Safety Guidelines, 2007. Section 3 regarding Community Health and Safety contains a section on Traffic Safety that includes general good practice health and safety measures, e.g. limiting vehicle speeds, maintaining vehicles, providing driver training, etc. These have generally been included in the mitigation measures presented in **Section 14.7**.

14.3 Assessment Methodology

The potential impacts for traffic and access have been assessed qualitatively and are based on visits to the study area to identify traffic conditions and a review of predicted traffic movements during BMP construction and operation.

In this assessment, impact significance is considered to fall into one of only two categories: not significant or significant. In the absence of established significance criteria for traffic and access impacts, professional judgment has been used to assess whether the impacts on traffic and access are considered to be significant or not. Professional judgment has considered the magnitude and duration of the impact.

The receptors considered in the assessment are the users of local roads. There are no residential communities other sensitive receptors that are considered receptors in context of traffic impacts as the Refinery and BMP are accessed directly from main roads. Hence the impact considered is purely the contribution of the BMP to local traffic volumes, congestion and road safety.

Mitigation and monitoring measures proposed include any specific measures indicated by the assessment as well good international industry practice measures in respect of traffic management and road safety.

The assessment has not considered BMP construction work or operational changes at Sitra Tank Farm and Sitra Wharf. This is because the proposed construction work and operational changes at these locations are relatively minor and access is good from Shaik Jaber A. Al Sabah Highway. Hence, there are no expected significant adverse traffic impacts. However, these sites will be covered by the good practice mitigation measures identified.

14.4 Baseline

Figure 14.2 presents an overview of the current traffic situation in the vicinity of the Refinery.

Traffic accesses the current Bapco Refinery from the Nuwaidrat and ALBA roundabouts. Traffic is often congested in both of these areas. The BMP site is located to the east of King Hamad Highway, within the current Bapco boundary. Access to the BMP site and the Pitch Ponds is via the King Hamad Highway at the junction with ALBA. The King Hamad Highway is a major dual carriageway.

As of early 2016, road improvement construction work has commenced on the ALBA and the Nuwaidrat roundabouts. When complete, the ALBA roundabout will consist of a 3-level interchange and the Nuwaidrat roundabout will be a 2-level interchange. The works are expected to be completed in 2018 and are expected to greatly reduce congestion in the area (**Figure 14.1**).

Figure 14.1 Proposed Interchanges at Alba and Nuwaidrat Roundabouts

Alba Interchange

Nuwaidrat Interchange

The Roads Directorate also plans to upgrade King Hamad Highway and Shaikh Jaber Highway at unspecified dates in the future to 3-4 lanes in each direction together with grade separated junctions.

Traffic volumes for 2010, 2016 and 2020 have been provided from the MWMAUP National Planning and Development Strategy 2030 (NPDS) Model created by W.S Atkins for the section of King Hamad Highway which adjoins the ALBA roundabout and passes ALBA and Bapco sites. The volumes are presented in **Table 14.1**.

Table 14.1 Traffic Flows on King Hamad Highway

Duration	2010 (measured)		2016 (measured)		2020 (predicted)	
	From ALBA R/A	To ALBA R/A	From ALBA R/A	To ALBA R/A	From ALBA R/A	To ALBA R/A
	Numbers of Vehicles					
24 hrs	19,737	22,462	35,662	38,607	46,279	49,370
Morning 06.30-07.30	1,487	1,173	3,475	2,186	4,800	2,861
Afternoon 13.00-14.00	1,448	1,345	2,129	2,738	2,583	3,667
Evening 16.30-17.30	1,357	1,391	2,061	2,868	2,531	3,852

Traffic volumes on King Hamad Highway are relatively high and averaged 160 vehicles per hour in 2016. Given the industrial nature of the area, the traffic comprises a large proportion of HGVs and worker transportation (minibuses, coaches).

Title: Traffic - Existing Situation			Client: Bapco Technip
Project: Bapco Modernization Program			
Date: May 2015	Figure No.: 14.2		Consultant: Environment Arabia
Datum: WGS 84 - UTM 39N	Scale: 1:35,000 (A4)		

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14.5 Project Traffic Design Proposals

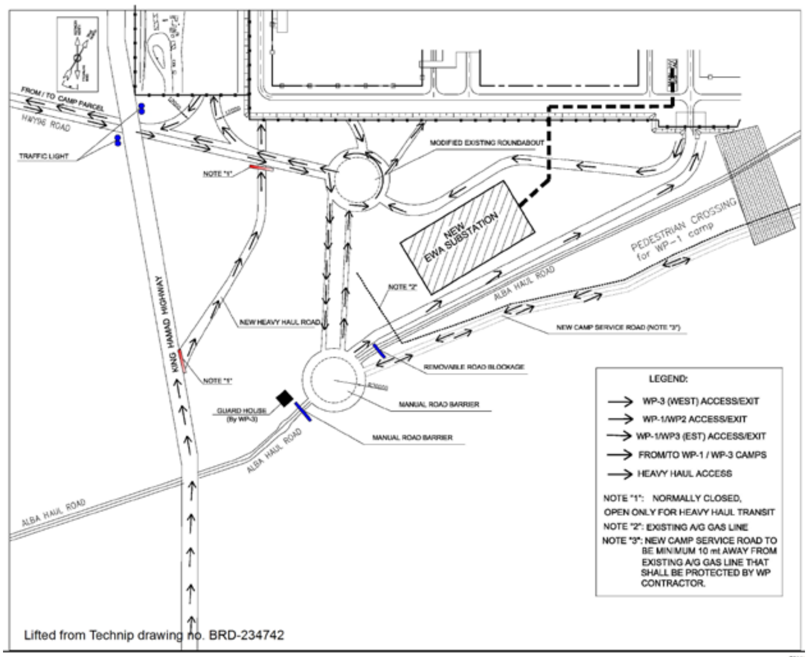
14.5.1 Construction

14.5.1.1 Construction Site Access

Figure 14.3 shows the provisional access arrangements for BMP construction to the south of the BMP site. It is reproduced below as an inset for ease of reference. The access would also provide access to the two labour camps that are proposed to be located to the south of the Refinery. The proposed access has been designed to improve access both in terms of traffic volumes and road safety and forms part of the traffic and access mitigation.

A new road for heavy vehicles would be constructed off King Hamad Highway for vehicles travelling northbound, which would have provision to be closed during times of non-use. A new roundabout would be installed along the ALBA Haul Road from which new access roads would be constructed into the camp site and connecting with the existing roundabout to the south of the Pitch Ponds Site. One-way traffic only is provided for on some of the new and existing access roads to reduce the risk of accidents. Provision for pedestrians to cross the camp access road and ALBA Haul Road from the camp site will be provided by means of a bridge.

Figure 14.3 Access to BMP Site (Reproduced from Figure 2.,11)



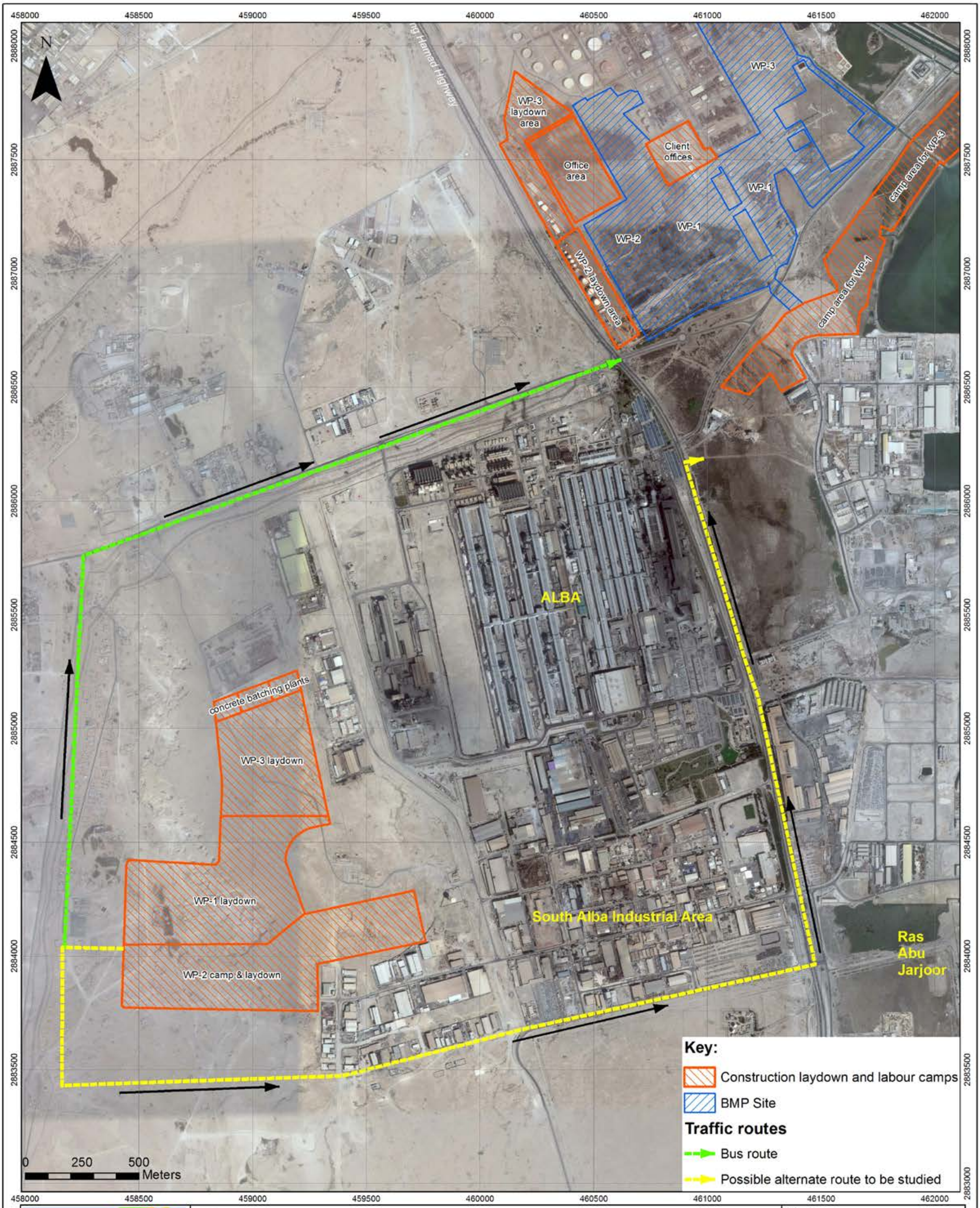
14.5.1.2 Labour Camp to West of ALBA

Figure 14.4 shows the preferred traffic route from the labour camp west of ALBA to the BMP site, plus an alternative route. Traffic will leave the camp from the western perimeter and be routed north along a two-lane, metalled, existing road providing access to the oil field from Avenue 96 (Junction 2 on **Figure 14.2**). Traffic would turn right onto Avenue 96 and travel to the junction with King Hamad Highway (Junction 1). Alternatively, traffic would turn south out of the labour camp, following the existing road for approximately 600m (Junction 3) before being routed on a new road heading east towards Road 5156 which runs south of the South ALBA Industrial Estate. Road 5156 connects with King Hamad Highway (Junction 4) and from here traffic can access the BMP from the ALBA Haul Road or new Heavy Haul Road.

14.5.1.3 Traffic Management within Labour Camps

The following measures will be adopted during construction within the labour camps:

- Circulation routes and emergency exits for emergency vehicles will be clearly indicated and provided for.
- Construction vehicles will not be allowed to park within the labour camp.
- Adequate parking will be provided based on the following:
  - Junior and senior staff areas - 0.5 bays per accommodation unit.
  - Labourer areas - predominantly bus parking, calculated on the basis of the total labour population, divided by the number of labourers per bus as a guideline.
- Walking distance to the nearest bus stop / parking area will be limited to a maximum distance of 400 m.
- Barriers will be provided at bus embarkation/disembarkation points to separate pedestrians from vehicles.
- Adequate lighting will be provided.



Title: **Traffic Route from Labour Camp West of Alba**		Client: Bapco, Technip
Project: Bapco Modernization Program		
Date: May 2015	Figure No.: 14.4	Consultant: Environment Arabia
Datum: WGS 84 - UTM 39N	Scale: 1:15,000 (A4)	

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14.5.1.4 Access for Oversized Loads

Equipment for the BMP weighing over 80 tonnes will not be transported to the BMP site by road; instead it will be transported by sea to a local jetty and then the final short distance to site will be by road. This approach will minimize the road traffic impact of the transportation of oversized loads.

Oversized loads will be transferred from the port of entrance in Bahrain - Prince Khalifa Bin Salman or Mina Salman Port - by barge to either the Muharraq Engineering Jetty or a similar jetty close to the BMP site. **Figure 14.5** presents the locations of the preferred jetty and transport route. A list of oversized loads is shown in **Table 14.2**.

Along the route from the jetty to the BMP site, some modifications are expected to be necessary to allow oversized loads to be transported such as: gate and boundary wall removal; culvert strengthening; overhead cable lifting and temporary removal of traffic lights.

Table 14.2 Provisional List of Oversized Loads

Item	Qty	L (m)	W (m)	H (m)	Weight (tonne)
Atmospheric Column VPII	1	60	11	11	615
Vacuum Column VPII	1	54	11.5	11.7	450
1st Train Reactor VPI	2	53	5	5	1,050
2nd Train Reactor VPI	2	53	5	5	1,000
1st Stage Reactor VPII	1	45	5.6	5.6	1,250
2nd Stage Reactor VPII	1	36	4.6	4.6	570
Product Fractionator VPII	1	66	7.35	7.35	330
Product Fractionator VPII	1	55	6	6	180
C3 Storage Bullets (1)	1	60	7	10	380
C3 Storage Bullets (2)	1	60	7	10	380
C4 Storage Bullets (1)	1	60	7	10	290
C4 Storage Bullets (2)	1	60	7	10	290
Off Spec / Spare LPG Storage Bullets (1)	1	60	7	10	380
Off Spec / Spare LPG Storage Bullets (2)	1	60	7	10	380

Title: **Location of Preffered Jetty and Transport Route for Oversized Loads**		Client: Bapco Technip
Project: Bapco Modernization Program		
Date: May 2015	Figure No.: 14.5	Consultant: Environment Arabia
Datum: WGS 84 - UTM 39N	Scale: 1:10,000 (A4)	

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14.5.2 Operation

14.5.2.1 Operation Access

Access to the BMP during operation will be via a new access gate in the south west corner of the site. Up to 600 workers will require access to the site on a daily basis, plus deliveries and visitors.

14.6 Assessment of Impacts

14.6.1 Construction

14.6.1.1 Site Preparation

It is anticipated that the site preparation will commence in late 2016 and continue for one to two years. The Pitch Ponds site will be raised from approximately 2 m AOD to 5 m AOD and this will require the import of almost 1,500,000m^3 of suitable fill material. The source, and therefore the transportation route, for this material is unknown at this stage of the project. However, the FEED has provided options for sources of fill, aimed at reducing the required traffic movements. If the fill material is transported by road using 40m^3 trucks, in excess of 30,000 truck movements will be required. This is considered to be a potentially significant impact. Depending on the route, there is potential for temporary adverse impacts on the local road network particularly on the Nuwaidrat and ALBA Roundabouts, Junction 1 and the King Hamad Highway. The contractor responsible for the filling will need to prepare a detailed Traffic Management Plan (TMP) to mitigate any potential impacts.

14.6.1.2 Transport of Construction Workers

Construction workers will be transported to site by bus from the labour camps. Based on a workforce of 5,000 leaving the west camp, there will be a requirement for 100 bus trips to transport them. These will occur at the beginning and end of each shift; however, the times are as yet unspecified. These movements are considered to be a potentially significant impact. Depending on whether the buses are routed to the north or south of ALBA, all four junctions noted on **Figure 14.2** may be impacted.

From the labour camp south of the Pitch Ponds site, construction workers will either be transported by bus or will walk to the site using the pedestrian bridge. These movements will not have an impact on the local road network and are not considered to be significant.

14.6.1.3 Transport of Oversized Loads

Oversized loads from Muharraq Jetty (or similar location) will be transported by road firstly through an industrial area, then along King Hamad Highway to enter the site at Junction 1. Fourteen oversized BMP plant items have been identified at this stage. Although this is not a significant number, the impact of their transport is considered to be significant. There would be a temporary adverse impact on King Hamad Highway. Careful consideration is needed regarding the timing of this transportation in conjunction with the Ministry of Interior to minimize its impact.

14.6.1.4 Construction Plant, Equipment, Materials and Waste

Construction plant, equipment, materials and non-hazardous solid waste would need to be transported on a daily basis to and from the laydown areas located within the western and eastern camps. Furthermore, a concrete batching plant will be located in the western camp. It is assumed that wastewater from the camp will not be transported offsite for treatment. Vehicle movements associated with this will be generated throughout the day and night and are considered to be not significant, although they will require careful management to avoid disruption to the local road network, e.g. restricting deliveries during peak hours. As a good international industry practice measure, the transportation of all plant, equipment and materials to and from site should be included within a TMP.

14.6.2 Operation

Up to 600 workers are expected to be required for the operation of the BMP. Some of these will be transported to work in buses, but there will also be a requirement for private vehicles to have access to the site. In addition, there will be vehicle movements associated with deliveries and visitors to the BMP. These movements are predicted to be not significant, given the established main road network around the BMP, the current improvements to ALBA and Nuwaidrat roundabouts, and the construction of new dedicated access roads to the BMP.

14.7 Mitigation

The creation of new access to the BMP site prior to construction will improve both access safety and capacity throughout the life of the project. The minimization of the distances for the transportation of oversized loads by road will also reduce traffic impacts from this aspect of the project. These are both significant traffic mitigation measures that are part of the BMP design. In addition management measures will be required in the form of TMP(s).

TMP(s) will be required for all construction activities and should be adopted by all construction contractors. Measures that should be incorporated into the TMP(s) are:

- Provision of additional plans for oversized load movements.
- Requirements to liaise with local law enforcement with respect to traffic management.
- Provision of a traffic plan for heavy equipment/major items during construction by the EPC contractor to be made available to concerned stakeholders.
- Provision of a traffic access map to send to all contractors and suppliers involved in the construction phase.
- Consideration of the reduction of HGVs during the morning, afternoon and evening peak/rush hour times.
-
- Routing of construction plant and vehicles away from residential areas.
- Provision of sufficient advanced notice of all traffic diversions and road closures, together with details of whom to contact at the construction site in the case of complaints.
- Clear signing of all diversions.
- Provision of designated delivery and loading/unloading areas.

- Inspection of local roads prior to construction and provision for the contractor to make good any damages.
- Sweeping of all roads contaminated with sand/dust.
- Fencing off frequently used haul routes within the construction zone to keep pedestrians out.
- Provision of clearly marked pedestrian walkways.
- Restricting the speed of construction vehicles to reduce dust generation.
- Switching off engines/equipment when not in use.
- Regular maintenance of vehicles.
- Ensuring all workers are familiar with the Traffic Management Plan and receive sufficient information, instruction, training and supervision.

14.8 Monitoring

The implementation of the TMP(s) should be monitored routinely throughout the construction phase.

14.9 Summary

A summary of the predicted impacts for traffic and access is provided in **Table 14.3**.

Table 14.3 Summary of Traffic and Access Impacts

Impact	Significance	Mitigation/Enhancement Measures	Residual Impact
Construction			
Site Preparation	Significant	-Improved access for BMP. -Transport oversized load by sea close to site as practicable. -Implement TMP.	Significant - Short periods of increased congestion.
Transport of Construction Workers	Significant		
Transport of Oversized Loads	Significant		
Construction Plant, Equipment and Materials	Not Significant	Implement TMP	Not Significant
Operation			
Transport of workers, deliveries and visitors	Not Significant	Improved access for BMP.	Not Significant

The site preparation, transport of construction workers from the western labour camp to site and transportation of oversized loads will all require particular measures to minimize the potential impact on local traffic conditions. These will be presented in TMPs to be prepared and implemented by the relevant contractors. The content of such plans are identified in the mitigation section. Should these measures by implemented then traffic impacts should be minimized but it is likely that there will be short periods of congestion during the construction phase but there should be no impact on road safety.

15 WASTE MANAGEMENT

15.1 Introduction

The chapter includes consideration of solid and liquid wastes generated from all phases of the BMP including: construction; commissioning; operation; maintenance; decommissioning and demolition, but not wastewaters discharged to surface waters or sewer.

15.2 Legislation and Guidance

15.2.1 National

15.2.1.1 Public Commission for the Protection of Marine Resources, Environment and Wildlife, Resolution No. 3 of 2006 with Respect to the Management of Hazardous Wastes

Resolution No. 3 of 2006 highlights the acceptable methods of waste collection, storage, handling, transportation, treatment, disposal, recycling and reuse. The purpose of the Order is to implement a scheme to supervise the generation, transport, storage, treatment and disposal of hazardous wastes, to ensure the protection of human health and the environment. Amongst others, the Order applies to producers of hazardous wastes. A framework is provided for the definition of waste types and the classification of hazardous waste.

Inert waste – Waste of chemically or biologically inactive materials in the natural environment. Such wastes can include glass, building debris, plastic parts, wood, rubber, wires or metal plates, and uncontaminated soil which is free of plants.

Non-hazardous industrial waste – Any solid, semi-solid, or liquid materials not containing gaseous materials that result from mining, agricultural operations or slough resulting from agricultural or mining industries, water supply plants, sewage water treatment stations or filters used in air pollution control provided that they shall not be contaminated by hazardous waste.

Hazardous wastes – waste that may lead to a hazard or potential hazard to public health, environment, and wildlife because of their quantity, concentration, physical, chemical, or biological properties when they are managed in an environmentally improper manner. Such wastes include the following:

- All waste having the characteristics or properties mentioned in Appendix 3, 4, 5 and 6 of Resolution No. 3 of 2006 with respect to the Management of Hazardous Materials.
- Any waste that exceeds the standard concentration mentioned in Appendix 5 of Resolution No. 3 of 2006 after carrying out the Toxicity Characteristic Leaching Procedure.
- Any other waste defined by the SCE.

15.2.1.2 Ministerial Order No.10 of 1998 with Respect to Fees for Licences Issued by the Environment Affairs Authority and the Services it Provides

This legislation sets out fees for disposal of hazardous and semi-hazardous waste and also requires companies transporting these types of waste to obtain an annual licence.

15.2.1.3 Public Commission for the Protection of Marine Resources, Environment and Wildlife Resolution No 3 of 2005 with Respect to Environmental Standards in Workplaces

The resolution applies to any site or establishment in which activity is being undertaken that is likely to be a source of pollution or environmental degradation.

Amongst other things, the Resolution requires an employer to separate industrial wastes from other types of waste and to approach the Waste Management Section of the SCE to be advised as to how to properly dispose of industrial wastes.

15.2.1.4 Public Commission for the Protection of Marine Resources, Environment and Wildlife Resolution No. 4 of 2006 with Respect to the Management of Hazardous Chemicals

Resolution No. 4 puts in place an appropriate monitoring and management system for the management of hazardous chemical materials listed in Ministerial Order No.7 of 2002 with respect to control import and use of banned and strictly restricted chemicals and any other chemicals specified by the SCE under this Regulation, with a view to eliminating or limiting the spread of its effects that are harmful to human health and the environment.

15.2.1.5 Public Commission for the Protection of Marine Resources, Environment and Wildlife Resolution No 4 of 2005 with Respect to Used Oils Management

The resolution introduced a supervision and control scheme for storage, transportation and processing of used oils and disposal thereof (excludes oils containing Polychlorinated Biphenyls (PCBs) or otherwise unsuitable for recycling). The resolution requires:

- Documentation of oils being transported, including a carrier form completed by the oil producer;
- Only licensed carriers to transport oil; and
- Oil treatment or disposal to be licensed.

15.2.1.6 Law No. 21 of 1996 regarding the Environment

Article 11 requires that projects or individuals undertaking digging, excavation, construction and demolition activities must take precautions to prevent environmental damage, in particular the measures relating to storage, transport, and safe disposal of waste.

15.2.1.7 Law No 11 of 1992 ratifying the 1989 Basel Convention regarding the Control of Transboundary Movements and Disposal of Hazardous Waste

The Basel Convention is principally devoted to establishing a framework to control the movement of hazardous wastes across international borders. It also developed the criteria for “environmentally sound management” and focused on the minimisation of waste generation.

A guiding principle of the Convention is that hazardous wastes should be dealt with as close to where they are produced as possible. International movements of wastes can only take place following prior written notification by the State of export to the competent authorities of the States of import and every country that the waste passes through (if appropriate). Such movements may be required, if the state of export does not have the capability of managing or disposing of the hazardous waste in an environmentally sound manner. The export of hazardous waste from Bahrain to another country is considered the least favourable option.

15.2.2 International Guidance

15.2.2.1 IFC Performance Standard 3 - Resource Efficiency and Pollution Prevention (IFC, 2012)

IFC Performance Standard 3 states that the client (the party responsible for implementing the project) should avoid the generation of hazardous and non-hazardous waste materials. Where waste generation cannot be avoided, the client should reduce the generation of waste, and recover and reuse waste in a manner that is safe for human health and the environment.

Where waste cannot be recovered or reused, the client should treat, destroy, or dispose of it in an environmentally sound manner that includes the appropriate control of emissions and residues resulting from the handling and processing of the waste material. If the generated waste is considered hazardous, the client should adopt good international industry practice alternatives for its environmentally sound disposal while adhering to the limitations to its transboundary movement.

When hazardous waste management is conducted by third parties, the client will use contractors that are reputable and legitimate enterprises licensed by the relevant Government regulatory agencies and obtain chain of custody documentation to the final destination. The client should ascertain whether licensed disposal sites are being operated to acceptable standards and where they are, the client will use these sites. Where this is not the case, clients should reduce waste sent to such sites and consider alternative disposal options, including the possibility of developing their own recovery or disposal facilities at the project site.

15.2.2.2 World Bank General Environmental Health and Safety Guidelines: Environmental (World Bank, 2007a)

Section 1.6 addresses waste management and requires the following measures of facilities that generate and store wastes:

* Establishing waste management priorities at the outset of activities based on an understanding of potential environmental, health, and safety (EHS) risks and impacts and considering waste generation and its consequences;
* Establishing a waste management hierarchy that considers prevention, reduction, reuse, recovery, recycling, removal and finally disposal of wastes;·
* Avoiding or minimizing the generation waste materials, as far as practicable; ·
* Where waste generation cannot be avoided but has been minimized, recovering and reusing waste; and
* Where waste cannot be recovered or reused, treating, destroying, and disposing of it in an environmentally sound manner.

It also provides general guidance on good practice requirements for management of waste including implementing Duty of Care tracking of wastes to their final reuse/recycling/recovery or disposal.

15.2.2.3 World Bank EHS Guide: Environmental, Health and Safety Guidelines for Petroleum Refining (World Bank, 2007b)

The guidelines for petroleum refining require the following management of spent catalysts:

* Use long life catalysts and regeneration to extend the catalyst life cycle;
* Use appropriate on site storage and handling methods; and
* Return spent catalysts to the manufacturer for regeneration or recover, or transport to other off site companies for heavy or precious metal recovery.

Other hazardous wastes generated in the refining process should be managed as follows:

* Send oily sludges from the crude oil storage tanks and the desalter to the delayed cooking drum, where applicable, to recover hydrocarbons;
* Ensure excessive cracking is not conducted in the visbreaking unit to prevent production of unstable fuel oil, resulting in increased sludge sediment formation during storage;
* Maximize recovery of oil from sludges; and
* Sludge treatment may include land application or solvent extraction followed by combustion of the residue and / or use in asphalt. Residue may require stabilization prior to disposal.

Non-hazardous wastes such as neutralization sludges which may contain calcium fluoride, calcium hydroxide, calcium carbonate, magnesium fluoride, magnesium hydroxide and magnesium carbonate, should be marketed for steel mills use or landfilled.

Other process wastes should be tested and classified as hazardous or non-hazardous based on local regulatory requirements.

Environment Arabia

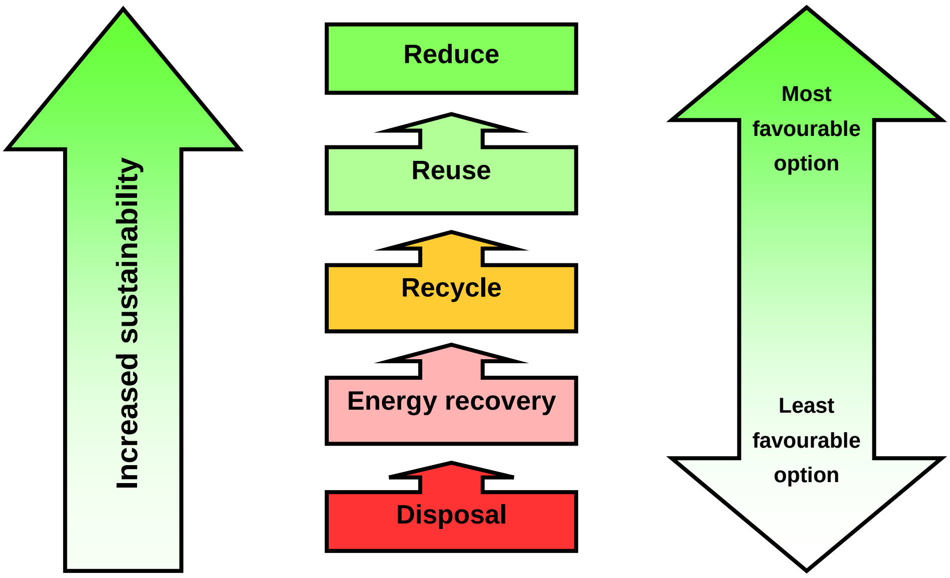
15.2.2.4 World Bank EHS Guidelines for Crude Oil and Petroleum Product Terminals (World Bank, 2007c)

The IFC waste management guidelines for crude oil and petroleum product terminals sets out the requirements for management of wastes generated at these locations. The typical wastes generated are tank bottom sludge, spill cleanup materials and soils contaminated with oil. Tank sludge and spill cleanup materials should be managed by reprocessing for product recovery. Small amounts of oil contaminated soil can be managed at licensed facilities. Larger quantities should be managed in accordance with contaminated land principles.

15.2.2.5 European Union Waste Framework Directive (2008/98/EC) (European Commission, 2008)

The Directive formally establishes the waste hierarchy as the basis for the management of wastes across the European Union and these principles can be applied in the wider international context where similar principles have not been formally implemented. The waste hierarchy is shown in **Figure 16.1**.

Figure 15.1 Waste Hierarchy



15.3 Assessment Methodology

15.3.1 Impact Assessment Significance Criteria

Environmental impacts associated with waste disposal have been classified on a seven point scale from major adverse, moderate adverse, minor adverse through to negligible and on to minor beneficial, moderate beneficial and major beneficial. For a project to achieve beneficial impacts in respect of waste the project would need to be a net consumer of waste. Adverse impacts arise from the generation of waste from the project.

Environment Arabia

Significance criteria have been developed based on the waste type - hazardous, non-hazardous or inert (i.e. its potential to cause harm to human health and/or the surrounding environment), factored with the quantities of waste generated per year. The criteria are summarised in **Table 15.1**. The classification assumes that all solid waste is landfilled. Diversion of waste from landfill and up the waste hierarchy can be considered to be mitigation which will reduce its environmental impact and render it negligible. Where there is no other practicable option, then the disposal of waste to a licenced landfill under full Duty of Care requirements is considered suitable mitigation to reduce its environmental impact to negligible. In respect of wastewaters, the assessment criteria are not applicable and expert judgment has been used to determine the predicted scale of impact.

Table 15.1 Waste Management Significance Criteria

Waste Type	Impact Significance				
Hazardous	Minor adverse	Minor adverse	Minor adverse	Moderate adverse	Major adverse
Non hazardous	Negligible	Negligible	Minor adverse	Minor adverse	Moderate adverse
Inert	Negligible	Negligible	Negligible	Minor adverse	Minor adverse
Quantity (tonnes per year)	<1	1 - 10	10 – 100	100-1000	>1000 or requiring export from Bahrain

15.4 Baseline

15.4.1 Operational Waste Types and Quantities

The waste streams generated by Bapco currently are detailed in **Table 15.2.** The data provided is all of the waste generated during 2014 and represents the baseline for wastes generated on site. This information was taken from Bapco's annual report to the SCE regarding chemical use and waste production. A copy of the 2014 report is included as **Appendix 15A**.

Most of the waste material generated by the Refinery is of the chemical type (e.g. process catalysts. These have mainly been stored on site pending further treatment, reclamation, reusing and/or recycling. The largest quantities of waste are non-hazardous contaminated soil from construction works and equilibrium catalyst (FCCU E-Cat), followed by asphalt from construction works and hazardous oil sludge. These wastes are also stored on site, while some are reprocessed/reused/recycled. Smaller quantities of hazardous waste such as coke, lead battery acid, sludge/scale and certain catalysts are generated by the Refinery and stored on site for appropriate treatment and disposal with the exception of lead acid batteries which are recycled off-site by a licenced contractor.

In addition to these wastes there will be commercial type wastes including office waste and canteen waste.

Table 15.2 Waste Generated by Bapco Refinery in 2014

Waste	Source	Type: Solid (S), Liquid (L)	Classification	Quantity (tonnes)
Spent Process Catalysts				
Spent Zinc Oxide catalyst	LSFO Complex	S	Non Hazardous	5.6
Steam Methane Reforming (SMR) spent catalyst	LSFO Complex	S	Hazardous	12.7
HTS spent catalyst	LSFO Complex	S	Hazardous	36.8
LTS spent catalyst	LSFO Complex	S	Hazardous	29.8
Methanation spent catalyst	LSFO Complex	S	Hazardous	9.1
2HDU Reactor R6201 CoMo/NiMo spent catalyst	LSFO Complex	S	Hazardous	207.6
2HDU Reactor R6301 CoMo/NiMo spent catalyst	LSFO Complex	S	Hazardous	208.2
2HDU Reactor R6300 NiMo spent catalyst	LSFO Complex	S	Hazardous	47.1
2HDU Reactor R6200 NiMo spent catalyst	LSFO Complex	S	Hazardous	46.3
Equilibrium spent catalyst	FCCU	S	Non Hazardous	904
1HCU spent catalyst (Penta-Rings)	LSDP	S	Non Hazardous	3.1
1HCU spent catalyst	LSDP	S	Hazardous	326.8
Zinc Oxide spent catalyst	LSDP	S	Non Hazardous	13.3
CoMo spent catalyst	LSDP	S	Hazardous	1.5
Activated carbon	Treating Section	S	Non Hazardous	15.2
Claus alumina spent catalyst	Treating Section	S	Non Hazardous	48.9
Spent poly catalyst	Utilities Group	S	Hazardous	68.4
Sub-total Spent Catalysts				1984.4
Oily Materials				
Heavy oil tank sludge and miscellaneous solid waste	Utilities Group	S+L	Non Hazardous	10.4
Sludge / scale	CDU	S+L	Hazardous	5.7
Sludge / sand	HDU	S+L	Hazardous	10.4
Oily sludges	Utilities Group	S+L	Hazardous	113.4
Oily sludges	Utilities Group	S+L	Hazardous	801.1

Waste	Source	Type: Solid (S), Liquid (L)	Classification	Quantity (tonnes)
Sub-total Oily Materials				941
Other Wastes				
Inert ceramic balls	LSDP	S	Non Hazardous	38.4
Spent Alumina dessicant from sahara air driers	Utilities Group	S	Non Hazardous	3.2
Asphalt-based tank pads	Utilities Group	S	Non Hazardous/Hazardous	848.2
Coke	VBU	S	Hazardous	3
Lead acid batteries	Utilities Group	S	Hazardous	1.2
Contaminated soil from construction work	Utilities Group	S	Non Hazardous / Hazardous	920.3
Sub-total Other Wastes				1814.3
TOTAL				4739.7

15.4.2 Bapco Waste Management Infrastructure

15.4.2.1 Class 1 Landfill

Bapco has a landfill within the Refinery site that is designed to receive hazardous waste and is compliant with US Environmental Protection Agency requirements for Class 1 (hazardous waste landfills). The landfill as part of Bapco's Hazardous Waste Management Facility will be used to receive stabilized hazardous wastes. The landfill has a capacity of 68,000m^3 and has a minimum design life of 10 years. It will receive stabilized lead contaminated waste and other suitable hazardous Refinery wastes.

15.4.2.2 Waste Stabilization Plant

Associated with the landfill there is a waste stabilization plant as part of Bapco's Hazardous Waste Management Facility that will be used to pre-treat hazardous wastes prior to their disposal to the Class 1 landfill. The unit will be used principally to stabilize lead-contaminated waste using as proprietary stabilizing agent. The plant has a capacity of 40m^3 per day.

15.4.2.3 Contaminated Soil Storage

Contaminated soil from previous construction projects is stored in a specially designed area in the east of the Refinery. The storage area is lined with a flexible membrane liner to prevent seepage of any contamination into underlying soil and groundwater.

15.4.2.4 Storage of Oil Contaminated Sludges

Oil contaminated sludges are stored in raised ponds that are located in the eastern part of the Refinery. The ponds are lined with a flexible membrane liner to prevent seepage of contamination. These ponds are a temporary storage measure until new treatment and reprocessing facilities are in place.

15.4.2.5 Scrap Metal Storage

Scrap metal is stored in a secure yard located at the south end of the Refinery. Periodically the area is cleared of scrap which is recycled.

15.4.2.6 General Wastes

General production wastes, canteen wastes and office wastes are collected in skips located around the site and removed as commercial waste by a Bapco approved waste contractors.

15.4.3 Waste Management Contract

Bapco are proposing to implement a new hazardous waste management contract that will create a safe means of treating/disposing of hazardous wastes.

The hazardous waste management contract comprises:

- A contractor operating and managing the Bapco Class 1 landfill and collecting and characterizing all of the hazardous waste streams generated at the Refinery, Sitra and Wharf areas.
- Maintenance and operation of the Bapco stabilization unit, where wastes contaminated with inorganic lead will be stabilized and disposed of safely to the Class 1 landfill.
- Legacy oily contaminated sludges will be treated in order to remove hydrocarbons to acceptable levels in order to safely dispose or reuse them. This is likely to require thermal treatment or incineration of oil contaminated sludges.

This contract is not part of the BMP but this assessment assumes it will be in place prior to implementation of the BMP and will be considered as the baseline circumstance for the BMP.

15.5 Impact Assessment

15.5.1 Construction Phase

Construction and commissioning waste have been addressed together as the solid wastes generated from these activities are expected to be very similar. Also these phases are likely to overlap as some units continue to be constructed whilst others are commissioned. Commissioning is likely to give rise to additional, temporary waste water streams in respect of cleaning pipelines and vessels. These are also considered.

Preliminary estimates of construction and commissioning waste quantities are provided in **Table 15.3**. These waste quantities are order of magnitude estimates only and are based on professional judgment. These figures should be considered <u>indicative</u> of the likely quantities only. More accurate estimates are not available as the scheme is only at FEED stage and also, benchmark data for waste quantities from similar construction projects are not available.

In general, the BMP process units will be constructed off-site at suppliers' facilities. This will reduce the amount of construction waste generated on site.

Table 15.3 Waste Management and Impact Mitigation Proposals

Waste Types	Source	Quantity (tonnes)
Soils – inert	Pipeline excavation, piling	1,000-10,000
Contaminated soils – non hazardous and hazardous	Excavation, piling	10,000-100,000
Concrete - waste	Excess deliveries, mixer truck washout	1,000-10,000
Metal	Off-cuts	1,000-10,000
Wood	Packaging	1,000-10,000
Bentonite or drilling polymer – non-hazardous	Piling	100-1,000
Asphalt	Road and car park construction	10-100
Plastics and packaging		1,000-10,000
Other general wastes – inert and non-hazardous construction wastes		1,000-10,000
Hazardous wastes – waste oils, batteries, etc.	Vehicle and equipment maintenance	10-100
Wastewater / sewage from site offices to septic tanks– non-hazardous	Bathrooms/ kitchen facilities	500,000 (m^3)
Wastewater / sewage from labour camps	Bathrooms/ kitchen facilities	2,000,000 (m^3)
Wastewater from commissioning	Cleaning pipes and vessels	10,000-100,000 (m^3)
Canteen wastes	Food waste, plastic drink bottles, metal cans	1,000-10,000
Office waste	Waste paper, food waste, plastic drink bottles, metal cans, toner cartridges, IT electrical waste	100-1,000

General, non-hazardous construction waste can be segregated to separate out metals, plastics, wood and paper which can then be collected as separate waste streams and recycled. It is expected that a residue of mixed general construction wastes will remain which cannot be effectively segregated. This material can be sent for disposal to Askar landfill which is authorized to receive non-hazardous commercial waste.

Construction will potentially give rise to a small amount of hazardous wastes comprising such things as used lubricating oils and used batteries from servicing construction plant. These materials can generally be recycled but otherwise landfilled. Transportation of hazardous waste can only be carried out by a licensed carrier and must be taken to a facility licensed to manage hazardous waste.

The majority of dry office and canteen wastes can be recycled provided they are segregated from each other at source. Food waste cannot be recycled and no suitable facilities exist in Bahrain to compost or otherwise treat food waste and this will require disposal to landfill.

The construction site offices will have sanitary portable toilet blocks. Wastewater will need to be collected in septic tanks which will require to be regularly emptied and wastewater tankered to a designated sewage treatment works for treatment.

Where possible, wastewater from construction labour camps will be discharged directly to municipal sewer provided there is capacity available. As an alternative, package sewage treatment plants (STP) would be used to treat wastewater from labour camps. Treated effluent from the labour camp STPs at the Refinery site (WP1 and 3) would be discharged to sea or used for landscape irrigation. Treated effluent from WP2 (west of Alba) would be tankered off site for disposal (at a municipal STP or through WP1 and 3 and discharge to sea) or would be used for landscape irrigation. The design of the wastewater treatment system will be finalized by the EPC contractor. Discharges to sewer would require permission from the Ministry of Works, Sanitary Engineering Planning and Projects Directorate (SEPPD). Any discharge to surface water would be regulated by SCE and would be part of the overall environmental permission for the project.

Wastewater from commissioning will consist of water used to clean vessels and pipework and will contain treatment chemicals such as chlorine as well as small amounts of grit and dirt. It is proposed that this material is stored on site, chemically tested to ensure it meets the national effluent standards and treated in the Bapco WWTP or discharged directly to sea as a process wastewater.

Waste management proposals for these wastes are summarised in **Table 15.4** together with mitigation proposals to reduce or minimise their impact.

Table 15.4 Construction Phase Waste Management and Impact Mitigation Proposals

Waste Stream	Environmental Impact Before mitigation	Waste Management Proposal (mitigation)	Environmental Impact After mitigation
Soils – inert	Minor Adverse	Reuse in construction on or off-site.	Negligible
Contaminated soils - Hazardous	Major Adverse	Treated to render it non-hazardous and reused or disposed to landfill.	Negligible
Contaminated soils - Non hazardous	Moderate Adverse	Treated and reused.	Negligible
Concrete - waste	Moderate Adverse	Reuse in construction on or off-site.	Negligible
Metal	Minor Adverse	Recycling off-site.	Negligible
Wood	Moderate Adverse	Recycling on-site then recycling by others / disposal.	Negligible

Waste Stream	Environmental Impact Before mitigation	Waste Management Proposal (mitigation)	Environmental Impact After mitigation
Bentonite or drilling polymer – non-hazardous	Minor Adverse	Reuse.	Negligible
Asphalt	Minor Adverse	Recycling on-site / take back by supplier.	Negligible
Plastics and packaging	Moderate Adverse	Recycling.	Negligible
Other general wastes – inert and non-hazardous construction wastes	Moderate Adverse	Small quantities of unsegregated materials - disposed to landfill.	Negligible
Hazardous wastes – waste oils,	Minor Adverse	Recycling.	Negligible
Wastewater / sewage from site offices– non-hazardous	Moderate Adverse	Collection in septic tanks and tankering to municipal STP.	Negligible
Wastewater / sewage from labour camps	Moderate Adverse	Treatment in STP and disposal to sewer.	Negligible
Wastewater from commissioning	Minor Adverse	Storage on site, testing and discharge to sea via Bapco WWTP if needed.	Negligible
Canteen wastes	Moderate Adverse	Packaging recycled. Food waste disposed to landfill.	Negligible
Office waste	Minor Adverse	Packaging recycled. Food waste disposed to landfill.	Negligible

Many of the waste streams are classified as having a moderate adverse impact before mitigation. This is because the quantities of waste predicted are large because of the scale of the project. The majority of these waste streams can be reused or recycled to avoid landfilling and hence their predicted impact can be reduced to negligible. To achieve this outcome, waste streams will need to be segregated at source and handed over to a range of specialist waste management contractors. Inevitably there will be a residue of mixed wastes that are not reuseable or recyclable and these will require disposal to landfill.

15.5.2 Operational Phase

The BMP process units will produce limited solid wastes. Most solid wastes will be generated during maintenance periods when equipment is shutdown, cleaned and inspected. For processes that use catalysts, maintenance will also include periodic replacement of the catalyst. BMP units that will require catalyst replacement are:

- No. 1 Residue Hydrocracking - Unit will produce an estimated 4,878 tonnes per year of spent catalyst which is a hazardous waste. The preferred disposal route is to return the used catalyst to the manufacturer but this will be confirmed later in the project design process.

- No. 2 Hydrocraking Unit - will require its catalyst to be changed once every three years. The predicted quantity of catalyst is 805 tonnes (268 tonnes as an annual average). It is expected that the used catalyst will be recycled for use as a catalyst or will be processed to remove heavy metals from the catalyst by a specialist contractor. This will be confirmed later in the project design process.

- No. 3 Hydrodesulphurization Unit - will require its catalyst to be changed once every three years. The predicted quantity of catalyst is 350 tonnes (117 tonnes as an annual average). The used catalyst is likely to require landfilling as a hazardous waste.

Other than these materials, the BMP will also result in increased amounts of sludges and scales and other general production wastes.

The closure and decommissioning of units, including the FCCU, will lead to a considerable reduction in quantities of related wastes.

Based on 2014 waste data and the identified process changes as a result of the BMP, , the solid industrial wastes quantities predicted to be generated from the Refinery, post-BMP are shown in **Table 15.5**. These quantities have been calculated by removing specific wastes streams from processes that will be decommissioned as part of the BMP (e.g. FCCU catalyst) and proportionately increasing the quantity of general waste types in accordance with the proportionate increase in Refinery capacity. Quantities of spent catalysts that are produced less frequently than annually have been calculated on an annual waste quantity basis (e.g. No. 2 Hydrocraking Unit - will require its catalyst to be changed once every three years. The predicted quantity of catalyst is 805 tonnes or 268 tonnes as an annual average). The calculated quantities are a preliminary estimate and assume that the waste quantities generated in the baseline year, 2014, are relatively typical and that waste quantities will increase in proportion with the Refinery capacity.

In addition to these wastes there will be office wastes and canteen wastes which are not quantified.

Table 15.5 Predicted Industrial Waste Streams, Post-BMP

Waste Type	Pre-BMP (tones per year)	Post-BMP (tonnes per year)	Notes
Spent catalysts	1,984	6,275	Mixture of Hazardous and Non Hazardous Wastes
Oily materials - Sludges / scales	941	1,269	Hazardous
Other waste	1,814	2,432	Mixture of Hazardous and Non Hazardous Wastes
Total	4,740	9,975	

Table 15.6 shows the predicted impacts for the total Refinery waste streams post-BMP. The table shows that hazardous waste streams will be initially treated on-site to reduce any hazardous properties prior to disposal. Where possible, waste catalysts will be sent back to the manufacturer for recycling or treatment and disposal.

Table 15.6 Predict Impact of Refinery Waste Streams, Post-BMP

Waste Stream	Environmental Impact Before Mitigation	Waste Management Proposal (mitigation)	Environmental Impact After Mitigation
Spent catalysts	Major Adverse	Recycling to supplier or disposal to on-site hazardous waste landfill.	Negligible
Oily materials - sludges / scales	Major Adverse	Off-site reprocessing/recycling on-site treatment to reduce waste classification to non-hazardous and disposal to municipal landfill.	Negligible
Other industrial wastes	Major Adverse	Disposal of non-hazardous waste to landfill. Recycling of batteries. Treatment of hazardous wastes and disposal to municipal landfill.	Negligible
Office waste	Minor Adverse	Packaging recycled. Food waste disposed to landfill.	Negligible
Canteen wastes	Moderate Adverse	Packaging recycled. Food waste disposed to landfill.	Negligible

15.5.3 Decommissioning and Demolition

Decommissioning of redundant Refinery plant will give rise to similar wastes to the production process: oily wastes; used catalysts together with wastewaters from cleaning processes. Demolition will give rise to large quantities of steel, electrical cabling and electrical equipment, brick and blocks. There will also be some asbestos waste from insulation and other sources. And some general office and canteen wastes. At this stage the waste streams have not been quantified. The expected types of waste and the proposed waste management methods are shown in **Table 15.7** together with the predicted impacts. The predicted impacts have been derived using expert judgment.

Table 15.7 Decommissioning and Demolition Waste Streams and Predicted Impacts

Waste Stream	Environmental Impact Before Mitigation	Waste Management Proposal (mitigation)	Environmental Impact After Mitigation
Wastewater from cleaning	Moderate Adverse	Disposal to Refinery wastewater treatment system	Negligible
Oily sludges and scales	Major Adverse	Off-site reprocessing/recycling, on-site treatment to reduce waste classification to non-hazardous and disposal to municipal landfill.	Negligible
Asbestos	Moderate Adverse	Disposal to hazardous landfill.	Negligible
Building rubble	Minor Adverse	Reuse brick and block as fill. Dispose of remainder to non-hazardous waste landfill.	Negligible
Insulation	Minor Adverse	Disposal to non-hazardous waste landfill.	Negligible
Electrical wiring and equipment	Minor Adverse	Recycling of copper and other metals.	Negligible
Spent catalysts	Major Adverse	Recycling to supplier or disposal to on-site hazardous waste landfill.	Negligible
Steel and other metals	Minor Adverse	Recycling.	Negligible

15.6 Mitigation

15.6.1 Construction and Commissioning Phase

To implement the mitigation measures identified and to successfully divert construction wastes away from landfill, requires that the following measures are integrated into the project CESMP and implemented by all contractors and sub-contractors.

1. Manage all waste in accordance with Duty of Care principles.
2. Appoint a member of the contractor's management team as Waste Manager.
3. Waste Manager to ensure that a process is put in place to segregate construction wastes – at least metals, paper/card, plastics, wood, residual general construction wastes and hazardous wastes to be placed in separate skips or containers.
4. Clearly label skips and containers to ensure effective segregation.
5. Ensure that sufficient skips are provided and that skips are emptied regularly.

6. Waste Manager to regularly inspect skip contents and police segregation. Waste Manager to ensure that effective corrective actions are put in place.
7. Complete Waste Management Manifests and liaise effectively with SCE in respect to the transport and treatment or disposal of any hazardous wastes.
8. Obtain copies of licences for hazardous waste carriers, waste oil carriers and waste oil recycling facilities (do not pass these wastes to un-licenced operators).
9. Keep any hazardous wastes separate from non-hazardous and inert wastes.
10. Waste should be stored so they do not cause environmental pollution.
11. Hazardous waste should be stored, packaged, labeled and transferred in accordance with requirements of Resolution No. 3 of 2006 with respect to the management of hazardous wastes.
12. Waste Manager to ensure that food waste and other “wet wastes” are segregated from other “dry” canteen and office waste streams (e.g. paper, soda cans).
13. Waste Manager to promote office and canteen waste recycling by segregating food waste, metal, paper and plastic. Remove desk-side waste paper bins and provide central segregated bins.
14. Do not burn wastes on site.
15. Ensure toilet blocks are used and are kept clean. Ensure that septic tanks are regularly emptied.
16. Provide training within the site induction regarding requirements for the segregation of wastes.
17. Maintain manifests and similar such records (e.g. invoices) to demonstrate where the waste has been taken to for treatment.
18. Maintain summary records to be updated monthly showing:
    - the quantities of each waste produced during the month.
    - identifying whether the waste has been reused, recycled, recovered or disposed.
19. Wastewaters from commissioning which may contain hazardous materials (e.g. chlorine, biocides) should be stored on site and tested to determine that they comply with discharge limits before disposal.

15.6.2 Operational Phase

Operational phase requirements for waste management are already implemented by Bapco and these arrangements will also be implemented by the BMP. In summary the main elements are:

1. Manage all waste in accordance with Duty of Care principles.
2. All hazardous waste to be transported by licenced carriers.
3. All wastes to be disposed of at licenced landfills only.
4. All wastes to be treated by licenced treatment facilities only.
5. Records (transfers notes or invoices) should be maintained for all waste loads.
6. Report quantities of wastes generated to SCE annually.

15.6.3 Decommissioning and Demolition Phase

The waste management mitigation requirements in respect of decommissioning and demolition are the same as those for construction and commissioning with the following additions:

1. All buildings which may contain asbestos (built prior to June 1996) will require a destructive asbestos survey prior to demolition.
2. Any asbestos, including documented asbestos lagging and other materials will need to be removed by a specialist contractor.
3. Permission for removal of asbestos must be obtained from SCE.

15.7 Monitoring

This is applicable to all phases of the project.

In line with good international industry practice a log of the types and quantities of waste produced should be maintained on a routine basis including how the waste was managed, i.e. reused, recycled, recovered or disposed. Records of all waste transactions should also be maintained. Copies of licences for hazardous waste carriers, treatment and disposal sites should also be maintained. During operation an annual waste and chemical use return should be made to the SCE.

Implementation of the identified mitigation measures should be verified by site audits and inspection of records.

15.8 Summary

A summary of the predicted impacts in respect of waste management of waste management is provided in **Table 15.8**.

15.9 References

(European Commission, 2008) European Union Waste Framework Directive Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on waste and repealing certain Directives.

(IFC, 2012) Performance Standards on Environmental and Social Sustainability. International Finance Corporation 2012. http://www.ifc.org/performancestandards. Accessed 29th May 2106.

(World Bank, 2007a) General EHS Guidelines. http://www.ifc.org/ehsguidelines. Accessed 29th May 2106.

(World Bank,: 2007b) Environmental, Health, and Safety Guidelines for Petroleum Refining. http//www.ifc.org/ehsguidelines. Accessed 29th May 2106.

(World Bank, 2007c) Environmental, Health, and Safety Guidelines for Crude Oil and Petroleum Product Terminals. http://www.ifc.org/ehsguidelines. Accessed 29th May 2106.

Table 15.8 Summary of Waste Impacts

Impact	Significance (Minor/Moderate/Major) (Beneficial/Adverse/Negligible)	Mitigation / Enhancement Measures	Residual Impacts (Slightly/Moderate/Major) (Beneficial/Adverse/Negligible)
Construction and commissioning wastes	Minor to Moderate Adverse	Implement a construction phase waste management plan. Proactively manage waste. Segregate waste at source to maximise recycling and reuse opportunities. Manage waste responsibly - maintain Duty of Care.	Negligible. Most waste streams can be minimised, reused or recycled. Only limited non-hazardous waste streams will require disposal.
Operational wastes	Major to Minor Adverse	Recycling of used catalysts. On site waste treatment for hazardous wastes and disposal to off-site non-hazardous landfill. Segregation and recycling of commercials wastes to maximise recycling. Reporting waste quantities to SCE.	Negligible
Decommissioning wastes	Major to Minor Adverse	Recycling of used catalysts. On site waste treatment for hazardous wastes and disposal to off-site non-hazardous landfill. Segregation and recycling of commercials wastes to maximise recycling.	Negligible

16 CHEMICALS

16.1 Introduction

This chapter considers the use and storage of new chemicals required for the BMP. The SCE require that developers provide details of all chemicals that will be used in a project to demonstrate that no banned chemicals are intended to be used, also to facilitate the required environmental permitting for import and use of the proposed chemicals. The section also considers the use of chemicals and fuels in construction and operation of the BMP to identify requirements for their safe storage and use. Where new product storage is required, general requirements for their environmentally safe storage, which is consistent with BAT principles, are highlighted.

Requirements for hazard assessment during design (e.g. hazard assessment and consequence analysis for uncontrolled releases) and emergency response planning are addressed in **Section 20 Occupational Health and Safety**. Management of emissions of VOCs from the BMP, including storage tanks are addressed **Section 6 Air Quality**.

The issue of Naturally Occurring Radioactive Materials (NORM) has been specifically mentioned by the SCE in their letter responding to the ESIA Scoping Report (see **Appendix 5B**). Within the oil and gas industry, NORM is regarded as an issue associated with oil and gas production where produced water or gas from a well may contain very low concentrations of NORM which precipitate or form scales in equipment and pipework over long periods of time: effectively concentrating the NORM and creating a potential radiation exposure hazard. There is no experience in the industry of NORM being a significant issue at refinery facilities and sites. Guidance on NORM produced by the Canadian Association of Petroleum Producers (CAPP), June 2000 states that "NORM is not usually present in refining operations as oil production removes NORM contaminated water before delivery to the refinery". For this reason assessment of NORM has been scoped out of the ESIA.

16.2 Legislation and Guidance

16.2.1 Legislation

16.2.1.1 Legislative Decree No. 21 of 1996 in Respect to the Environment

The Decree provides the following measures to manage the use of hazardous materials:

Article 14: Handling of hazardous materials and waste without permission from SCE shall be prohibited.

Article 15: Persons concerned with the production and handling of hazardous materials whether in gas, liquid or solid form, shall comply with all the precautions and conditions determined by SCE to ensure that no damages would occur to the environment.

16.2.1.2 Ministerial Order No. 7 of 2002 with Respect to Controlling the Import and use of Banned and Restricted Chemicals

The Order sets out a list of banned and restricted chemicals whose import is prohibited or limited. Before commencement of the project the SCE require to review the list of proposed chemicals, including their full composition, to determine that the chemicals proposed to be used within the project do not contain banned substances.

16.2.1.3 Resolution No. 4 of 2006 with Respect to the Management of Hazardous Chemicals

Management of chemicals is also regulated under Resolution No. 4 of 2006. **Table 16.1** shows the relevant sections of the Resolution with respect to this project. This resolution is also applicable to fuel due to its flammability.

Table 16.1 Relevant Sections in Resolution No. 4 of the Year 2006 to this Study

Article	Details
Article 10 (labelling and handling)	1. A pack shall be large enough to accommodate an area sufficient to past all signs and the information label required pursuant to the MSDS and regulations to be determined by the SCE. 2. The labels shall be glued on every pack by a substance strong enough to withstand all normal transportation conditions, and to ensure that the label shall remain easily identifiable with clear information in Arabic and/or English in clean and legible characters that cannot be erased or damaged. 3. The hazard and handling labels shall contain indicative drawings in internationally recognised in words and warning signs in accordance with the applicable regulations: a. The name of the manufacturing company, contact address thereof in case of emergency and its registration number in the country of manufacture. b. Date of production and expiray date of the chemical substance contained in the pack. c. Chemical and commercial name, active substance, degree of purity and the nature of impurities, if any.
Appendix 1 (storage conditions)	The following recommendations are required to be implemented at the fuel and lube oil storage areas: 1. The storage area shall be designed in a way to minimize the risk of fire, spillage and injury and ensure the segregation of incompatible substances. 2. Providing emergency exits that are easily accessible especially in darkness or in cases of intense smoke. 3. No battery charging, thermal lamination or welding shall be performed in the storage area. 4. Preparing a plan showing the nature of the hazards in every part of the storage area that also includes a list of the places and the amounts of chemicals stored together with their hazardous characteristics. The plan shall also indicate the locations of: emergency equipment, spill kits, fire fighting equipment, emergency exits available and it shall be updated periodically

Article	Details
	and kept in a place away from the storage site. 5. The materials shall be stacked in a manner that shall not obstruct the movement of forklifts, handling equipment and emergency equipment 6. Spillages and leakages must be dealt with in accordance with the MSDS. 7. Spill kits must be provided and maintained in a working order. 8. All defective packs must be disposed of in an appropriate manner, as well as maintaining the cleanliness of the area at all times by removing the cardboards, wood and packaging materials and preventing the accumulation of dust upon storage packs. 9. Appropriate fire extinguishing equipment must be provided at easily accessible locations after consultation with the General Directorate of Civil Defence, as well as providing fire alarm system, which shall be tested periodically to ensure that they remain in a working order. 10. The operations at the store shall be supervised by a well-trained and experienced supervisor.

16.2.2 Guidance

16.2.2.1 World Bank EHS General Guidelines, 2007 and World Bank EHS Guidelines for Crude Oil and Petroleum Product Terminals, 2007

These references provide general guidance on storage design and handling requirements for hazardous materials that are in line with good international industry practice. They include recommendations for secondary containment, leak detection, spill prevention, venting and control of VOC emissions, management of drainage, design risk assessment (e.g. HAZOP) and emergency response planning requirements.

16.2.2.2 Integrated Pollution Prevention and Control Reference Document on Best Available Techniques on Emission from Storage, July 2006

Provides general guidance on good practice in design and operation of storage tanks, similar to the World Bank EHS Guidelines referenced above. VOC emission reduction requirements are specified in respect to the type of tank and its contents.

In respect of potential emissions to soil and groundwater through leaks and seeps:

i. BAT is to achieve a ‘negligible risk level’ of soil pollution from bottom and bottom-wall connections of aboveground storage tanks. However, on a case-by-case basis, situations might be identified where an ‘acceptable risk level’ is sufficient.

ii. BAT for aboveground tanks containing flammable liquids or liquids that pose a risk for significant soil pollution or a significant pollution of adjacent watercourses is to provide secondary containment.

iii. For building new single walled tanks containing liquids that pose a risk for significant soil pollution or a significant pollution of adjacent watercourses, BAT is to apply a full, impervious, barrier in the bund. (i.e. the bund walls and base will be impervious).

16.2.2.3 Commission Implementing Decision, 9/10/2014 Establishing BAT Conclusions for the Refining of Mineral Oil and Gas

The decision identifies BAT as floating roof storage tanks equipped with high efficiency seals or a fixed roof tank connected to a vapour recovery system. In respect of containment of liquid hydrocarbons one or more of the following is identified as BAT:

i. Maintenance programme including corrosion monitoring, prevention and control;
ii. Double bottomed tanks;
iii. Impervious membrane liners;
iv. Sufficient tank farm bund containment.

16.2.2.4 UK Pollution Prevention Guidance (PPG)

The UK Environment Agency has published pollution prevention guidelines that provide guidance on how to prevent pollution at demolition and construction sites (PPG 6). This includes good practice guidance on the storage and use of fuels and chemicals.

16.2.2.5 MSDS

All major chemical manufacturers use Material Safety Data Sheets (MSDS) to communicate hazards and precautions to be taken for the chemicals they supply. These are usually provided for all chemicals supplied.

16.3 Assessment Methodology

Where possible, the potential environmental and health impacts of chemicals have been assessed using a risk assessment methodology where risk is considered to be a function of the severity of the hazard inherent in the chemical and the likelihood of the hazard occurring, i.e.:

Risk (R) = Severity (S) x Likelihood (L)

Several classifications of severity and likelihood have been defined and used to classify risk as Low, Medium or High. The definition of each of these terms is shown in **Table 16.2**. For hazard severity, descriptions are provided for health, safety and environmental hazards. In respect of occupational health risks, the health severity has been defined based on comparison to advice provided in the product MSDS.

Where the risk assessment process identifies medium and high levels of risk then control measures will be required to further reduce the level of risk as far as possible. In all cases industrial H&S good practice and storing and using chemicals in accordance with the MSDS is the minimum requirement. Provided the risk is reduced to low then the environmental impact has been considered negligible.

Separate assessments have been carried out for construction and operational phases of the project.

There is no baseline for this assessment as it addresses chemicals to be used in construction and new chemicals to be used in the operational Refinery.

Table 16.2 Risk Classification Based on Hazard Severity and Likelihood

RISK RATING (R) Likelihood (L) x Severity (S)		HAZARD SEVERITY (S)				
		Negligible – 1 H&S: Very minor Injury, no absence from work. Environmental: Exposure below pollution thresholds	**Slight - 2** H&S: Minor injury requiring first aid treatment Environmental: minor release, drips, minor spills	**Moderate - 3** H&S: Injury leading to a lost time accident Environmental: minor release leading to damage to immediate environment	**Serious– 4** H&S: Involving a single death or serious injury Environmental: Major release likely to cause long term damage to site area	**Catastrophic- 5** H&S: Multiple Deaths Environmental: Major release likely to cause long term damage to a natural resource beyond site boundary
LIKELIHOOD OF OCCURRENCE (L)	**Very Unlikely - 1** A freak combination of factors would be required for an incident/accident to result	LOW 1	LOW 2	LOW 3	LOW 4	LOW 5
	Unlikely - 2 A rare combination of factors would be required for an accident/incident to result	LOW 2	LOW 4	LOW 6	MEDIUM 8	MEDIUM 10
	Possible – 3 Could happen when additional factors are present but otherwise unlikely to occur	LOW 3	LOW 6	MEDIUM 9	MEDIUM 12	HIGH 15
	Likely – 4 Not certain to happen but an additional factor may result in an accident/incident	LOW 4	MEDIUM 8	MEDIUM 12	HIGH 16	HIGH 20
	Very Likely - 5 Almost inevitable that an accident/incident would result	LOW 5	MEDIUM 10	HIGH 15	HIGH 20	HIGH 25

Risk Classification Descriptions

Colour	Risk Assessment Classification	Risk Description	Environmental Impact Classification
	Low Risk	Acceptable risk; however, methodologies should be reviewed to see if risk can be reduced further.	Negligible Environmental Impact
	Medium Risk	Task should only proceed with appropriate consultation with specialist personnel and safety team. Where possible the task should be refined to take account of the hazards involved or the risks should be reduced further prior to task commencement.	Minor to Moderate Environmental Impact
	High Risk	Task must not proceed. It should be redefined or further control measures put in place to reduce risk. The controls should be reassessed for adequacy prior to task commencement.	Moderate to Major Environmental Impact

16.4 Impact Assessment

16.4.1 Construction Phase

Construction and commissioning will involve the use of routine chemical substances expected of a major civil and mechanical engineering project such as: fuels, oils, paints and coatings, glues and mastics, insulation, etc. Many of these are not specified at present and most will not have hazardous properties but some, including those required during commissioning, will have hazardous properties (e.g. biocides).

The potential for environmental impacts from storage of fuels and chemicals during the construction stage is from spills or leaks to the environment or exposure of workers to toxic materials through contact, inhalation or ingestion. These potential impacts can be controlled by simple good international industry practice measures. Application of these measures can be considered to reduce the risk of spills or exposure to an acceptable level or negligible impact.

Table 16.3 provides a provisional assessment of the risks posed by fuels and chemicals used during construction and commissioning. This will require to be updated by the contractor(s) prior to commencing construction work.

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Table 16.3 Construction and Commissioning Phase Chemical Risk Assessment

Activity/ Chemical	Hazards	Risk Targets	Risk L	Risk S	Risk R	Control Measures	Residual Risk L	Residual Risk S	Residual Risk R	PPE & Comments
Diesel / petrol fuel / oil	Irritant Flammable	Construction workers	2	5	10	Store away from oxidizers. Keep from heat, sparks, and open flames. Store with MSDS. Trained operatives and PPE.	1	5	5	Impervious rubber gloves. Coveralls. Chemical goggles; also wear a face shield if splashing hazard exists. Eyewash fountains and safety showers must be easily accessible.
	Spills and leaks	Soil and groundwater, surface water	3	3	9	Store quantities in excess of 200 litres (1 barrel) in a secondary impermeable bund with a capacity of 110% of the vessel. Place smaller containers on drip trays. All generators to placed on metal drip trays of suitable size to retain spills and leaks. Implement a spill response procedure. Store spill response kits at all fuel storage locations. Clean-up any minor spills by removing fuel stained soil and proper disposal. No fuels to be stored within 10m of surface water features.	3	1	3	

Activity/ Chemical	Hazards	Risk Targets	Risk L	Risk S	Risk R	Control Measures	Residual Risk L	Residual Risk S	Residual Risk R	PPE & Comments
Paints / glues / mastics	Exposure to toxic vapours. Contact with irritants.	Construction workers	3	2	6	Use in well-ventilated area. Store with MSDS. Trained operatives and PPE.	1	3	3	As per MSDS.
Concrete	Inhalation of dust. Can cause burns and allergic skin reactions	Construction workers	3	2	6	Use of PPE.	1	3	3	Dust mask. Gloves. Coveralls. Dust proof goggles. Eyewash fountains and safety showers must be easily accessible.
	High pH wash out water	Soil and groundwater	5	3	15	Wash out concrete trucks to a lined pit and dispose of in compliance with Waste Management Plan.	5	1	5	
Bentonite (piling)	Irritant	Site workers	2	2	4	Keep dry. Store with MSDS. Trained operatives and PPE.	1	2	2	Dust mask. Gloves. Coveralls. Dust proof goggles. Eyewash fountains and safety showers must be easily accessible.

16.4.2 Operational Phase

The operational phase will require the use of a range of chemical agents for cleaning, corrosion protection and process use. **Table 16.4** provides a provisional list, but these are subject to change and additions as these will be specified by the design contractor and operator. **Appendix 16A** contains copies of MSDS for these substances. **Table 16.5** provides a risk assessment for use and storage of these chemicals.

The operational phase of the BMP will also require the construction of several new storage tanks for residue (from CDU), crude oil, naphtha and MTBE. These are identified in **Table 16.6** which provides a summary of their environmental hazards and specific physical control methods. In addition to these there will be a requirement to implement good practice management methods of inspection, measurement, testing and maintenance to ensure containment systems remain effective. A MSDS for MTBE is included in **Appendix 16A**: the other materials listed in **Table 16.6** are already in use at the Refinery. Additional new storage tanks for LPG (pressurized vessels and double wall refrigerated tanks) are also part of the BMP but these are only of concern in respect of emissions of VOCs to air which are addressed in **Section 6**.

This list and risk assessment will require to be updated prior to the operation of the BMP. It will be the EPC contractor's responsibility to provide details of the full composition of all chemicals, including MSDSs to the SCE to demonstrate that the BMP is not using any banned substances, and to obtain specific approval if it is required to use any restricted chemicals.

Table 16.4 Operational Phase Chemical Agents

Name	Use	CAS No.	Estimated Monthly Consumption (tonnes)	Major Constituents	Physical Form
Sodium Bisulphite	P	7631-90-5	4.92	$NaHSO_3$ (40%) water solution	L
Sulphuric acid	P	7664-93-9	TBC	Sulphuric acid	L
Antifoam	P	TBC	0.12	TBC	L
Belgard EV	A	TBC	10.0	Aqueous solution of a synthetic polymer based on hydrolysed maleic anhydride.	L
Hydrochloric acid solution (33%)	C	7647-01-0	3.0	Water and Hydrochloric acid	L
NaOH solution (47%)	P	7664-93-9	53.2	NaOH	L
Nalco Elimin-ox	CP	497-18-7	0.3	Carbohydrazide	L
Tri –ACT 1800 Neutralizing Amine	CP	108-91-8	4.3	Cyclohexylamine	L
		141-43-5		Monoethanolamine	
		5332-73-0		Methoxypropylamine	
Nalco 3DT129	CP	7664-38-2	2.5	Phosphoric Acid	L
		7646-85-7		Zinc Chloride	

Name	Use	CAS No.	Estimated Monthly Consumption (tonnes)	Major Constituents	Physical Form
Nalco 3DT120	A	TBC	2.5	TBC	L
Nalco 8506 plus	A	TBC	0.2	TBC	L
Nalco 7330	P	26172-55-4	2.0	5-Chloro-2-Methyl-4-Isothiazolin-3-one	L
		2682-20-4		2-Methyl-4-Isothiazolin-3-one	
		10377-60-3		Magnesium Nitrate	
NaClO solution -12%	P		82	Sodium Chlorite, Water, TBC	L
Methyldiethanolamine (MDEA)	P	105-59-9	TBC	Water and MDEA	L
Nickel Carbonyl	P	13463-39-3	TBC	Nickel Carbonyl	L
Corrosion Inhibitor (not specified)	CP	TBC	3	TBC	L
Demulsifier (not specified)	P	TBC	61.2	TBC	L
Phosphates (not specified)	CP	TBC	0.5	TBC	L
CFPP additive (not specified)	P	TBC	231.0	TBC	
Mono Acid – Lubricity Additive (not specified)	P	TBC	210.0	TBC	L
Ester – Lubricity additive (not specified)	P	TBC	135.0	TBC	L
1RHCU catalyst – GR737 and GR823B	P	1344-28-1	GR737 – 143.5 GR823B – 116.4	Aluminium Oxide	S
	P	7764-30-7		Aluminium Phosphate	S
	P	1313-27-5		Molybdenum Trioxide	S
	P	12004-35-2		Dialuminium Nickel Tetraoxide	S
	P	14177-55-0		Molybdenum Nickel Oxide	S
	P	1313-00-1		Nickle Monoxide	S
2HCU catalyst - ICR 100	P	9004-65-3	7.3	Hydoxypropyl methylcellulose	S
	P	TBC		Ammonium Molybdenum Tungsten Nickel Hydroxide	S
	P	107-21-1		Ethylene glycol	S
2HCU catalyst - ICR 132	P	1344-28-1	1.0	Aluminium Oxide	S
	P	7784-30-7		Aluminium Phosphate	S

Name	Use	CAS No.	Estimated Monthly Consumption (tonnes)	Major Constituents	Physical Form
	P	P15123-80-5		Aluminium Molybdenum Oxide	
	P	1313-27-5		Molybdenum Trioxide	S
	P	14177-55-0		Molybdenum Nickel Oxide	S
2HCU catalyst - ICR 161	P	1344-28-1	1.0	Aluminium Oxide	S
	P	7784-30-7		Aluminium Phosphate	S
	P	15123-80-5		Aluminium Molybdenum Oxide	S
	P	1313-27-5		Molybdenum Trioxide	S
	P	1313-99-1		Nickle Oxide	S
	P	12004-35-2		Nickel Aluminate	S
2HCU catalyst - ICR 180	P	1344-28-1	5.7	Aluminium Oxide	S
	P	1318-02-1		Zeolite	S
	P	1335-30-4		Aluminium Silicate	S
	P	1314-35-8		Tungsten Trioxide	S
	P	1313-99-1		Nickel Oxide	S
2HCU catalyst - ICR 250	P	1344-28-1	11.2	Aluminium Oxide	S
	P	7784-30-7		Aluminium Phosphate	S
	P	1318-02-1		Zeolite	S
	P	1314-35-8		Tungsten Trioxide	S
	P			Organic Acid, Nickel Salt	S
2HCU catalyst - ICR 512	P	1344-28-1	9.0	Aluminium Oxide	S
	P	7784-30-7		Aluminium Phosphate	S
	P	15123-80-5		Aluminium Molybdenum Oxide	S

Name	Use	CAS No.	Estimated Monthly Consumption (tonnes)	Major Constituents	Physical Form
	P	1313-27-5		Molybdenum Trioxide	S
	P			Polycarboxylic Acid	S
	P	14177-55-0		Molybdenum Nickel Oxide	S
	P			Polycarboxylic Acid, Nickel Salt	S
	P	1335-30-4		Aluminium Silicate	S
	P	12004-35-2		Nickel Aluminate	S
	P	1313-99-1		Nickel Oxide	S
	P	1344-28-1		Aluminium Oxide	S
	P	15123-80-5		Aluminium Molybdenum Oxide	S
	P	7784-30-7		Aluminimium Phosphate	S
	P	1335-30-4		Aluminium Silicate	S
	P	12004-35-2		Nickel Aluminate	S
2HCU catalyst - AT724G	P	1333-88-6	1.0	Cobalt Aluminate	S
	P	1313-27-5		Molybdenum Trioxide	S
	P	14177-55-0		Molybdenum Nickel Oxide	S
	P	13702-14-6		Cobalt Molybdenum Oxide	S
	P	1313-99-1		Nickel Oxide	S
	P	1307-96-6		Cobalt Oxide	S
	P	1313-27-5		Molybdenum Trioxide	S
2HCU catalyst - GSK-6A	P	14177-55-0	0.1	Molybdenum Nickel Oxide	S
	P	1313-99-1		Nickel Oxide	S
2HCU catalyst - GSK-9	P	1344-28-1	0.3	Aluminium Oxide	S

Name	Use	CAS No.	Estimated Monthly Consumption (tonnes)	Major Constituents	Physical Form
	P	1302-93-8		Mullite	S
	P	14808-60-7		Quartz (SiO2)	S
2HCU catalyst - GSK-19	P	1344-28-1	0.4	Aluminium Oxide	S
	P	1335-30-4		Aluminium Silicate	S
2HCU catalyst - Denstone (NORPRO Ceramic Support Media)	P	7631-86-9	6.5	Silica, Amorphous	S
	P	14808-60-7		Quartz (SiO2)	S
3 HDU Catalysts – KG 55	P	TBC	0.05	TBC	S
3HDU Catalysts - KF-542	P	1344-28-1	0.09	Aluminium Oxide	S
	P	1313-27-5		Molybdenum Trioxide	S
	P	1307-96-6		Cobalt Oxide	S
	P	1313-99-1		Nickel Oxide	S
3HDU Catalysts - KF-647	P	1344-28-1	0.15	Aluminium Oxide	S
	P	1313-27-5		Molybdenum Trioxide	S
	P	1313-99-1		Nickel Oxide	S
3HDU Catalysts - KF-757 and KF-767	P	1344-28-1	1.1	Aluminium Oxide	S
	P	1313-27-5		Molybdenum Trioxide	S
	P			Glycol	
	P	1307-96-6		Cobalt Oxide	S
	P	7784-30-7		Aluminium Orthophosphate	S
3HDU Catalysts - KF-860	P	1344-28-1	2.6	Aluminium Oxide	S
	P	1313-27-5		Molybdenum Trioxide	S
	P			Glycol	

Name	Use	CAS No.	Estimated Monthly Consumption (tonnes)	Major Constituents	Physical Form
	P	7784-30-7		Aluminium Orthophosphate	S
	P	1313-99-1		Nickel Oxide	S

Notes:

C – Cleaning	A – Anti- scaling	G – Gas
P – in Process	CP – Corrosion Protection	S – Solid
L – Liquid	TBC – To Be Confirmed	

Catalyst use is calculated assuming a minimum 3 year life span of the catalyst. Monthly use is estimated from the total volume of the catalyst charge required spread over 36 months.

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Table 16.5 Operational Phase Chemical Risk Assessment

Activity/ Chemical	Hazards	Risk			Control Measures	Residual Risk			PPE & Comments
		L	S	R		L	S	R	
Sodium Bisulphite	Produces sulphur oxides on heating or contact with acids. Reacts with acids and strong oxidants, causing fire and explosion hazard. The substance is a weak acid. Attacks metal.	2	3	6	Store away from acids and oxidizing agents.	1	3	3	Wear protective eye glasses and gloves when handling.
Sulphuric acid	Strong acid. Many reactions may cause fire or explosion. Risk of fire and explosion on contact with base(s), combustible substances, oxidants, reducing agents or water. Gives off irritating or toxic fumes (or gases) in a fire. Corrosive.	2	3	6	Separated from combustible and reducing substances, strong oxidants, strong bases and incompatible materials. May be stored in stainless steel containers. Store in an area having corrosion resistant concrete floor.	1	3	3	Wear protective eye glasses and gloves when handling. Avoid creation of mists.
Antifoam	TBC								
Belgard EV	Irritant	2	3	6	Appropriate PPE.	1	3	3	Wear protective eye glasses and gloves when handling
Hydrochloric acid solution (33%)	Strong acid. Liquid and mists are corrosive.	2	3	6	Keep separate from incompatible materials (bases). Store in a cool, well ventilated area with acid resistant floor.	1	3	3	Wear eye goggles, face shield, appropriate resistant gloves, apron and boots.

Activity/ Chemical	Hazards	Risk			Control Measures	Residual Risk			PPE & Comments
		L	S	R		L	S	R	
NaOH solution (47%)	Strong alkali. Corrosive.	2	3	6	Keep separate from incompatible materials (acids). Store in a cool, well ventilated area.	1	3	3	Wear eye goggles, face shield, appropriate resistant gloves, apron and boots.
Nalco Elimin-Ox	Irritant	2	2	4	Keep separate from incompatible materials (oxidizers, strong acids). Store in a cool place.	1	2	2	Wear protective eye glasses and gloves when handling.
Tri –ACT 1800 Neutralizing Amine	Irritant. Corrosive. Flammable.	2	4	8	Keep separate from incompatible materials (acids and oxidizers). Store in sealed containers away from heat and sources of ignition. Use proper grounding procedures.	1	4	4	Wear protective eye glasses and gloves when handling. Ground vessels before transferring or decanting.
Nalco 3DT129	Strong acid. Corrosive.	2	3	6	Keep separate from incompatible materials (bases).	1	3	3	Wear eye goggles, face shield, appropriate resistant gloves, apron and boots.
Nalco 3DT120	Irritant	2	2	4	Keep separate from incompatible materials (strong oxidizers and bases).	1	2	2	Wear protective eye glasses and gloves.
Nalco 8506 plus	TBC								
Nalco 7330	Corrosive	2	3	6	Keep separate from incompatible materials (strong oxidizers).	1	3	3	Wear eye goggles, face shield, appropriate resistant gloves, apron and boots.
Sodium Hypochlorite - 12%	Irritant, corrosive	2	3	6	Store in a well-ventilated space.	1	3	3	Wear eye goggles, face shield, appropriate resistant gloves.
Methyldiethanolamine (MDEA)	Irritant	2	2	4	Appropriate PPE.	1	2	2	Wear protective eye glasses and gloves.

Activity/ Chemical	Hazards	Risk			Control Measures	Residual Risk			PPE & Comments
		L	S	R		L	S	R	
Nickel Carbonyl	Extremely flammable. Toxic. Corrosive. Irritant. Carcinogen.	2	5	10	Store in a cool place. Keep separate from incompatible materials (strong oxidizers).	1	5	5	Wear eye goggles, face shield, appropriate resistant gloves, apron and boots. Use air supplied respirator if needed.
Corrosion Inhibitor (not specified)	TBC								
Demulsifier (not specified)	TBC								
Phosphates (not specified)	TBC								
CFPP additive (not specified)	TBC								
Mono Acid - Lubricity Additive (not specified)	TBC								
Ester - Lubricity additive (not specified)	TBC								
1RHCU catalyst – GR737 and GR823B	May cause cancer by inhalation. Sensitization through skin contact. Harmful - danger of serious damage to health through prolonged exposure.	2	5	10	Limited exposure. Changed a maximum of once every 3 years. Avoid creation of dust. Avoid inhalation of dust, avoid skin contact.	1	5	5	Wear protective glasses, appropriate resistant gloves and boots. Use appropriate respiratory or air supplied respirator if needed for longer exposure periods.
2HCU catalyst - ICR 100	May cause cancer by inhalation. Harmful - danger of serious damage to health through prolonged exposure. Irritating to eyes.	2	5	10	Limited exposure. Changed a maximum of once every 3 years. Avoid creation of dust. Avoid inhalation of dust, avoid skin contact.	1	5	5	Wear protective glasses, appropriate resistant gloves and boots. Use appropriate respiratory or air supplied respirator if needed for longer exposure periods.
2HCU catalyst - ICR 132	May cause cancer by inhalation. Sensitization through skin contact. Harmful - danger of serious damage to health through prolonged exposure.	2	5	10	Limited exposure. Changed a maximum of once every 3 years. Avoid creation of dust. Avoid inhalation of dust, avoid skin contact.	1	5	5	Wear protective glasses, appropriate resistant gloves and boots. Use appropriate respiratory or air supplied respirator if needed for longer exposure periods.

Activity/ Chemical	Hazards	Risk			Control Measures	Residual Risk			PPE & Comments
		L	S	R		L	S	R	
2HCU catalyst - ICR 161	May cause cancer by inhalation. Sensitization through skin contact. Harmful - danger of serious damage to health through prolonged exposure.	2	5	10	Limited exposure. Changed a maximum of once every 3 years. Avoid creation of dust. Avoid inhalation of dust, avoid skin contact.	1	5	5	Wear protective glasses, appropriate resistant gloves and boots. Use appropriate respiratory or air supplied respirator if needed for longer exposure periods.
2HCU catalyst - ICR 180	May cause cancer. Harmful - danger of serious damage to health through prolonged exposure. May cause serious eye damage. May cause an allergic skin reaction. May cause respiratory irritation.	2	5	10	Limited exposure. Changed a maximum of once every 3 years. Avoid creation of dust. Avoid inhalation of dust, avoid skin contact.	1	5	5	Wear protective glasses, appropriate resistant gloves and boots. Use appropriate respiratory or air supplied respirator if needed for longer exposure periods.
2HCU catalyst - ICR 250	May cause cancer by inhalation. Harmful - danger of serious damage to health through prolonged exposure. Irritating to eyes and respiratory system.	2	5	10	Limited exposure. Changed a maximum of once every 3 years. Avoid creation of dust. Avoid inhalation of dust, avoid skin contact.	1	5	5	Wear protective glasses, appropriate resistant gloves and boots. Use appropriate respiratory or air supplied respirator if needed for longer exposure periods.
2HCU catalyst - ICR 512	May cause cancer. Harmful - danger of serious damage to health through prolonged exposure. May cause serious eye irritation. May cause an allergic skin reaction. May cause respiratory irritation.	2	5	10	Limited exposure. Changed a maximum of once every 3 years. Avoid creation of dust. Avoid inhalation of dust, avoid skin contact.	1	5	5	Wear protective glasses, appropriate resistant gloves and boots. Use appropriate respiratory or air supplied respirator if needed for longer exposure periods.
2HCU catalyst - AT724G	May cause cancer. Harmful - danger of serious damage to health through prolonged exposure. May cause serious eye damage. May cause an allergic skin reaction. May cause respiratory irritation.	2	5	10	Limited exposure. Changed a maximum of once every 3 years. Avoid creation of dust. Avoid inhalation of dust, avoid skin contact.	1	5	5	Wear protective glasses, appropriate resistant gloves and boots. Use appropriate respiratory or air supplied respirator if needed for longer exposure periods.
2HCU catalyst - GSK-6A	May cause cancer by inhalation. Sensitization through skin contact. Harmful - danger of serious damage to health through prolonged exposure.	2	5	10	Limited exposure. Changed a maximum of once every 3 years. Avoid creation of dust. Avoid inhalation of dust, avoid skin contact.	1	5	5	Wear protective glasses, appropriate resistant gloves and boots. Use appropriate respiratory or air supplied respirator if needed for longer exposure periods.
2HCU catalyst - GSK-9	Toxic – other toxic effects. May dry skin and eyes.	2	2	4	Appropriate PPE.	1	2	2	Wear protective eye glasses and gloves when handling.

Activity/ Chemical	Hazards	Risk			Control Measures	Residual Risk			PPE & Comments
		L	S	R		L	S	R	
2HCU catalyst - GSK-19	No specific hazards noted.	2	1	2	Appropriate PPE.	1	1	1	Wear protective eye glasses and gloves when handling.
2HCU catalyst - Denstone (NORPRO Ceramic Support Media)	Irritant. Carcinogenic (contains silica)	2	5	10	Limited exposure. Changed a maximum of once every 3 years. Avoid creation of dust. Avoid inhalation of dust, avoid skin contact.	1	5	5	Wear protective glasses, appropriate resistant gloves and boots. Use appropriate respiratory or air supplied respirator if needed for longer exposure periods.
3 HDU Catalysts – KG 55	TBC								
3HDU Catalysts - KF-542	May cause cancer by inhalation. Sensitization through skin contact.	2	5	10	Limited exposure. Changed a maximum of once every 3 years. Avoid creation of dust. Avoid inhalation of dust, avoid skin contact.	1	5	5	Wear protective glasses, appropriate resistant gloves and boots. Use appropriate respiratory or air supplied respirator if needed for longer exposure periods.
3HDU Catalysts - KF-647	May cause cancer by inhalation. Sensitization through skin contact.	2	5	10	Limited exposure. Changed a maximum of once every 3 years. Avoid creation of dust. Avoid inhalation of dust, avoid skin contact.	1	5	5	Wear protective glasses, appropriate resistant gloves and boots. Use appropriate respiratory or air supplied respirator if needed for longer exposure periods.
3HDU Catalysts - KF-757 and KF-767	May cause cancer by inhalation. Sensitization through skin contact.	2	5	10	Limited exposure. Changed a maximum of once every 3 years. Avoid creation of dust. Avoid inhalation of dust, avoid skin contact.	1	5	5	Wear protective glasses, appropriate resistant gloves and boots. Use appropriate respiratory or air supplied respirator if needed for longer exposure periods.
3HDU Catalysts - KF-860	May cause cancer by inhalation. Sensitization through skin contact.	2	5	10	Limited exposure. Changed a maximum of once every 3 years. Avoid creation of dust. Avoid inhalation of dust, avoid skin contact.	1	5	5	Wear protective glasses, appropriate resistant gloves and boots. Use appropriate respiratory or air supplied respirator if needed for longer exposure periods.

Table 16.6 Operational Phase Risk Assessment – Crude Oil, Intermediates and Products Storage

Activity/ Chemical	Hazards	Risk Targets	Risk			Control Measures	Residual Risk			PPE & Comments
			L	S	R		L	S	R	
Storage of MTBE at Sitra Tank Farm.	Leaks or seeps	Soil and groundwater, surrounding surface water	3	5	15	Use a secondary impermeable bund with a capacity of 110%. Use leak detection system. Overfill alarms.	3	1	3	MTBE is highly soluble in water and is a persistent contaminant in groundwater. These measures are consistent with BAT.
New Naphtha storage tank at Sitra Tank Farm.	Leaks or seeps	Soil and groundwater, surrounding surface water	3	4	12	Use a secondary impermeable bund with a capacity of 110%. Use leak detection system. Overfill alarms.	3	1	3	These measures are consistent with BAT.
New crude oil storage tanks at Refinery	Leaks or seeps	Soil and groundwater, surrounding surface water	3	4	12	Use a secondary impermeable bund with a capacity of 110%. Use leak detection system. Overfill alarms.	3	1	3	These measures are consistent with BAT.
Residue tanks for RHCU	Leaks or seeps	Soil and groundwater, surrounding surface water	3	4	12	Use a secondary impermeable bund with a capacity of 110%. Use leak detection system. Overfill alarms.	3	1	3	These measures are consistent with BAT.

16.5 Summary

A summary of the predicted impacts in respect of chemical management is provided in **Table 16.7**.

Table 16.7 Summary of Chemical Impacts

Impact	Significance (Minor, Moderate, Major Adverse or Negligible)	Mitigation Measures	Residual Impacts (Minor, Moderate, Major Adverse or Negligible)
Construction and Commissioning			
Contractor to update chemicals risk assessment prior to commencement of construction and then review and update it as needed.	N/A	N/A	N/A
Storage of Fuels	Minor Adverse	Store away from oxidizers. Keep from heat, sparks, and open flames. Store with MSDS. Trained operatives and PPE. Store quantities in excess of 200 litres (1 barrel) in a secondary impermeable bund with a capacity of 110% of the vessel. Place smaller containers on drip trays. All generators to placed on metal drip trays of suitable size to retain spills and leaks. Implement a spill response procedure. Store spill response kits at all fuel storage locations. Clean-up any minor spills by removing fuel stained soil and proper disposal. No fuels to be stored within 10m of surface water features.	Negligible
Operation			
Contractor to provide a list of new chemicals and MSDS to be used in operations to SCE for approval.	N/A	N/A	N/A
New storage tanks to meet BAT (and Bahraini legal requirements).	Moderate to Major (depending on material to be stored.	Use a secondary impermeable bund with a capacity of 110%. Use bottom leak detection system. Overfill alarms.	Negligible

Impact	Significance (Minor, Moderate, Major Adverse or Negligible)	Mitigation Measures	Residual Impacts (Minor, Moderate, Major Adverse or Negligible)
Process chemicals, cleaning chemicals and anti-scaling chemicals.	Minor to Moderate (depending on chemical).	Use and storage of chemical in accordance with MSDS.	Negligible

17 ENERGY AND RESOURCE EFFICENCY

17.1 Background

The Bapco Refinery commenced operation in 1936 and was built to the standards of that period in terms of design and efficient use of resources. The Refinery has been improved and modernized periodically over time and each development has been carried out to the design and efficiency standards of the time.

The BMP has been designed to bring the Refinery into the 21st century. Two of the central themes of the BMP are: to make the Refinery more efficient; and to refocus the Refinery on marketable products, so that Bapco is better able to compete in the world market.

This section of the ESIA will consider the energy and resource efficiency of the Refinery both before and after the BMP and assess it by benchmarking performance against international guidance and norms. This assessment does not include consideration of the significance of the environmental impacts as in most cases there are no direct emissions to environmental media. Also most of the impacts e.g. emissions to air, waste etc. are already assessed in other sections of this ESIA.

17.2 Guidance

17.2.1 World Bank Environmental, Health and Safety Guidelines, General EHS Guidelines, 2007 (World Bank, 2007a)

Section 1.2 provides general guidance on energy conservation. It identifies a range of energy management techniques that can be applied to common unit operations across a wide range of industrial plants.

17.2.2 World Bank Environmental, Health and Safety Guidelines for Petroleum Refining, 2007 (World Bank, 2007b)

This document sets out resource efficiency targets for refineries. These are reproduced in **Tables 17.1** and **17.2**. These benchmarks are described as "*for comparative purposes only.*"

Table 17.1 Resource and Energy Consumption Benchmarks

Parameter	Unit	Industry Benchmark
Land Use(1)	Hectares	200-500
Total Energy(1)	MJ per Metric Ton of processed crude oil	2,100 – 2,900
Electric Power(1)(2)	KWh per Metric Ton of processed crude oil	25 - 48
Fresh Make-up Water	m^3 per Metric Ton of processed crude oil	0.07 – 0.14

Notes:
(1) Based in part on EU BREF for Refineries. Latest version is Best Available Techniques (BAT) Reference Document for the Refining of Mineral Oil and Gas Industrial Emissions Directive 2010/75/EU Integrated Pollution Prevention and control EUR 27140 EN 2015 (EU BREF, 2015)
(2) Greenfield facilities

Table 17.2 Emission and Waste Generation Benchmarks

Parameter	Unit	Industry Benchmark
Waste Water	m^3 per Metric Ton of processed crude oil	0.1 - 5
Emissions	Tons / million tons of processed crude oil	
Carbon dioxide		25,000 – 40,000
Nitrogen oxides		90 – 450
Particulate matter		60 – 150
Sulfur oxides		60 – 300
Volatile organic compounds		120 - 300
Waste		20 - 100
Notes: Based in part on EU BREF for Refineries		

17.2.3 IFC Performance Standards on Environmental and Social Sustainability, 2012 (IFC, 2012)

IFC Performance Standard 3 regarding Resource Efficiency and Pollution Prevention addresses energy conservation in new developments. The document requires that projects "*implement technically and financially feasible and cost effective measures for improving efficiency in its consumption of energy, water, as well as other resources and material inputs, with a focus on areas that are considered core business activities"*. Also: *"Where benchmarking data are available, the client will make a comparison to establish the relative level of efficiency".*

IFC Performance Standard 3 references acceptable performance as Good International Industry Practice (GIIP) as referenced in World Bank EHS Guidelines, 2007 and other internationally recognized sources.

17.2.4 Best Available Techniques (BAT) Reference Document for the Refining of Mineral Oil and Gas Industrial Emissions, Directive 2010/75/EU Integrated Pollution Prevention and control EUR 27140 EN 2015 (BREF, 2015)

The benchmark efficiency measures set out in **Tables 17.1** and **17.2** given in the WBG EHS Guidelines are stated to be based in part on the European Union (EU) BREF data.

The EU BREF sets out details of energy efficiency surveys of European refineries. Survey benchmarks from the BREF document are summarized in **Table 17.3** for comparison. Generally the WBG benchmarks are far more stringent that the data ranges given in the BREF document.

Table 17.3 BREF Energy and Resource Efficiency Survey Data

Parameter	Units	Benchmark
Total Energy	MJ per tonne of processed crude oil	2750 average
		1670 5th percentile
		3730 95th percentile
Electric Power	MJ per tonne of processed crude oil	Not provided

Parameter	Units	Benchmark
Fresh Make-up Water	m^3 per tonne of processed crude oil	0.160 average
		0.000 5th percentile
		0.659 95th percentile
Waste Water	m^3 per tonne of processed crude oil	5.89 average
		0.18 5th percentile
		25.53 95th percentile
Carbon dioxide	Tonnes / million tonnes of processed crude oil	100,000 – 400,000
Nitrogen oxides		60 - 500
Particulate matter		4 - 75
Sulfur oxides		30 - 1500
Volatile organic compounds		50 - 1000
Waste		10-2000
Data is taken from Figure 3.1, Table 3.2 and 3.3 in the BREF. Total energy may include electrical power although this is unclear in the BREF.		

17.3 Resource Efficiency Measures Included within the BMP Design

The BMP has been designed in line with current energy efficiency measures prevalent in design of comparable oil refineries. Key measures include:

- The new crude distillation and vacuum distillation unit (7CDU/VDU) has been designed as a single integrated unit to maximize heat recovery and to minimize the total heat exchange area.
- New furnaces will be highly energy efficiency and will incorporate heat recovery systems to generate steam from waste heat.
- Off-gases from process units across the BMP will be collected, treated and used as a fuel for the Refinery heating requirements. This will reduce the use of natural gas.
- Recovery of hydrogen from off-gas from process units to minimize the requirement for hydrogen production on site.
- Recovery of propane and butane from process off-gases to create LPG and recovery of naphtha from process off-gases.
- Excess high pressure steam from the hydrogen production plant will be fed to the Bapco high pressure steam system.
- Use of latest process control and instrumentation to optimize process efficiency.
- Use of a closed loop cooling system to reduce water use.
- Use of a flare gas recovery system to recover and reuse gas that would otherwise have been flared continuously.

17.4 Comparison of Energy and Resource Efficiency Pre- and Post-BMP

Table 17.4 provides a comparison of the Pre- and Post-BMP energy and resource efficiency in comparison to the WBG and BREF guidance.

The comparison shows that overall the energy and resource data compares well with the BREF survey data for European refineries but compares poorly to the WBG benchmarks. The reasons for this are complex, but the main factors are:

1) The data for the BMP includes the residual units for the existing Refinery which comprise a range of plant which are not new and have been constructed roughly between 1960s and early 2000s.

2) The BMP is a complex refinery which will produce high grade products demanded by the market place and so makes best value use of the crude oil it will refine. Consequently, the specific energy demand and specific emissions are relatively high compared the WBG benchmarks (and pre-BMP Refinery). By comparison the existing Refinery is less complex and overall produces products with a lower market value which may be exported for further processing (and emissions) elsewhere in the world.

With respect to specific parameters in **Table 17.4** the following comments can be made:

Land use - Post-BMP many existing Refinery units will be superseded and replaced by the BMP units. This will leave considerable areas of open space interspersed within the Refinery which are not accounted for within the calculation as these will be within the main Refinery footprint.

Total Energy Use – Energy use will increase post-BMP for the reasons given above. However, if the energy use is compared to the existing Refinery operation by way energy efficiency (Energy Efficiency Index) there will be an improvement of 28% (this includes additional electric power consumption) and the energy performance of the Refinery will compare favourably with its peers in other countries.

The problem with the measure MJ/ton crude or kWh/ton crude is that no account is taken for the complexity of the refinery, only the tonnage of crude processed. Generally the more complex the refinery, i.e. higher conversion units etc., the higher the energy demand to operate such process units. This is why refinery benchmarking providers, such as Solomon Associates, firstly “normalise” refineries into Equivalent Distillation Capacity (EDC®) which is the sum of all process units capacities multiplied by an index. Depending of the complexity of the process unit an index will be applied per process unit. For instance CDU will carry an index of around 1 while a hydrocracker could carry an index of around 6.8.

Each process unit will be allocated a standard energy, again the complexity of the process unit is taken into account when allocating standard energies. The total standard energy will be compared to the actual total energy to determine the Energy Efficiency Index. In this way, although two refineries might process the same volume of crude, the refinery with the higher complexity will be credited with a higher EDC® and a higher standard energy resulting in the energy efficiencies “been leveled to the same playing field". This makes it possible to recognise refinery's energy usage on its complexity rather than just on the crude rate.

Waste Water – Although the BMP will include a re-circulating cooling system with cooling towers, the existing Refinery units will continue to operate using a single pass cooling system. This makes the waste water value relatively high. It should be noted that the cooling water is returned to the sea relatively unchanged, except for an increase in temperature.

Emissions to air - These compare generally favourably with both the WBG benchmarks and BREF survey data. The value for nitrogen oxides is slightly higher than the WBG benchmark. This is because the data presented is for the whole post-BMP Refinery and includes older less efficient units.

In respect of carbon dioxide emissions, these are generally proportional to energy use. As the BMP is more energy intensive, carbon dioxide emissions are proportionately higher. The WBG benchmark is extremely stringent and appears unachievable without significant carbon mitigation measures which are not economically achievable for a single refinery to implement outside of industry-wide and international reduction programmes.

Waste – this does not allow for the possible recycling of wastes (e.g. catalysts, contaminated soil) which would reduce the total waste figure.

Table 17.4 Comparison of Refinery Energy and Resource Efficiency Pre- and Post-BMP with WBG Benchmarks and BREF Survey Data

Parameter	Unit	WBG Benchmark	BREF Survey	Pre-BMP	Post-BMP
Land Use(1)	Hectares	200-500		423	504
Total Energy(1)	MJ per tonne of processed crude oil	2,100 – 2,900	2750 average 1670 5th percentile 3730 95th percentile	2,818	3,339
Electric Power(1)(2)	KWh per tonne of processed crude oil	25 - 48	Not provided	37.8	81.6
Fresh Make-up Water	m^3 per tonne of processed crude oil	0.07 – 0.14	0.160 average 0.000 5th percentile 0.659 95th percentile	0.47	0.61
Waste Water	m^3 per tonne of processed crude oil	0.1 - 5	5.89 average 0.18 5th percentile 25.53 95th percentile	20.7	14.6
Carbon dioxide	Tonnes / million tonnes of processed crude oil	25,000 – 40,000	100,000 – 400,000	162,888	260,236
Nitrogen oxides		90 – 450	60 - 500	713	514
Particulate matter		60 – 150	4 - 75	153	114
Sulfur oxides		60 – 300	30 - 1500	612	195
Volatile organic compounds		120 - 300	50 - 1000	Not assessed	Not assessed
Waste		20 - 100	10-2000	357	556

Notes:

(1) Based in part on EU BREF for Refineries. Latest version is Best Available Techniques (BAT) Reference Document for the Refining of Mineral Oil and Gas Industrial Emissions Directive 2010/75/EU Integrated Pollution Prevention and control EUR 27140 EN 2015 (EU BREF, 2015)

(2) Greenfield facilities

17.5 Summary

The BMP will be a relatively complex Refinery which will produce highly refined products. These products are in demand in the world market and will bring the best value to Bapco and keep the Refinery competitive in the long term. Whilst total energy use will increase, on a like for like basis, post-BMP the Bapco Refinery will be 28% more efficient. For most other resources and emissions the BMP will result in reductions in specific emission rates.

17.6 References

(BREF 2015) Best Available Techniques (BAT) Reference Document for the Refining of Mineral Oil and Gas Industrial Emissions Directive 2010/75/EU Integrated Pollution Prevention and control EUR 27140 EN 2015

(IFC 2102) IFC Performance Standards on Environmental and Social Sustainability, 2012

(World Bank 2007) World Bank 2007a, World Bank, Environmental, Health and Safety Guidelines, General EHS Guidelines, 2007

(World Bank 2007) World Bank, Environmental, Health and Safety Guidelines for Petroleum Refining, 2007

18 SOCIAL AND COMMUNITY IMPACTS

18.1 Introduction

The BMP will lead to social and economic changes for the local community and Bahrain. The purpose of social impact assessment (SIA) is to predict the nature and magnitude of these changes and to identify mitigation and management measures to control any possible undesired outcomes.

This section considers the social and economic changes to the local and national community. Other human and social issues such as occupational health and safety, labour and working conditions and cultural heritage are addressed in separate sections of the ESIA. Other issues that may impact the health and wellbeing of the immediate community including environmental noise and odour emissions are also addressed in other sections of the ESIA.

Furthermore, stakeholder engagement and consultation is discussed in **Section 5**.

18.2 Legislation and Guidance

18.2.1 Bahrain Law

The Labour Law No. 36 of 2012 in particular Title VX, addresses occupational safety and health. Articles 171 and 172 of Title VX require all workers to undergo a medical prior to employment and to receive basic health care at the cost of the employer.

Article 176 requires businesses employing fifty workers or more to provide its workers with necessary social and cultural services to be agreed in consultation with the trade union or the workers' representatives. The relevant Minster will issue a decision in agreement with the General Confederation Workers Trade Unions in Bahrain on the determination of these services and their extent that must be provided.

18.2.2 International Finance Corporation Performance Standards (IFC, 2012)

IFC PS 1 Assessment and Management of Environmental and Social Risks and Impacts and IFC PS 4 Community, Health, Safety, and Security are both relevant guidance documents which provide advice on the lifetime management of facilities. **Table 18.1** provides relevant requirements from these documents that are applicable.

Table 18.1 Relevant IFC Requirements in Respect of Community, Health, Safety and Security

Topic	Requirement
IFC PS 1 – Emergency Preparedness and Response	Details of communication plan for Affected Communities. Assist and collaborate with potentially Affected Communities (especially where their participation and collaboration are required for an effective response). Provide appropriate information to Affected Communities.
IFC PS 1 – Monitoring and Review	Where appropriate, clients will consider involving representatives from Affected Communities to participate in monitoring activities (e.g. participatory water monitoring).

Topic	Requirement
IFC PS 4 - Community Health and Safety	The client will evaluate the risks and impacts to the health and safety of the Affected Communities during the project life-cycle and will establish preventive and control measures consistent with good international industry practice (GIIP), such as in the World Bank Group Environmental, Health and Safety Guidelines (EHS Guidelines).
IFC PS 4 - Infrastructure and Equipment Design and Safety	The client will design, construct, operate, and decommission the structural elements or components of the project in accordance with GIIP, taking into consideration safety risks to third parties or Affected Communities.
IFC PS 4 - Hazardous Materials Management and Safety	The client will avoid or minimize the potential for community exposure to hazardous materials and substances that may be released by the project.
IFC PS 4 - Community Exposure to Disease	The client will avoid or minimize the potential for community exposure to water-borne, water-based, water-related, and vector-borne diseases, and communicable diseases that could result from project activities.
	The client will avoid or minimize transmission of communicable diseases that may be associated with the influx of temporary or permanent project labour.
IFC PS 4 - Emergency Preparedness and Response	The client will assist and collaborate with the Affected Communities, local government agencies, and other relevant parties, in their preparations to respond effectively to emergency situations, especially when their participation and collaboration are necessary to respond to such emergency situations.

18.3 Assessment Methodology

18.3.1 Scope of Assessment

The concerns of local communities with respect to the development may be classified as socio-economic issues (e.g. employment and effect on public services), nuisance issues (impacting quality of life) and health impacts (impacts caused by chronic exposure to pollution). Nuisance issues can contribute to the precipitation of health impacts through stress. Many of these aspects are addressed elsewhere within the ESIA and will not be reassessed in this section. Potential impacts on local communities that are considered elsewhere in this ESIA are:

- Noise emissions (**Section 8**);
- Impact on ambient air quality and odour emissions including nuisance issues and concerns regarding chronic exposure to volatile chemicals (**Section 6**);
- Major accident hazards (**Section 21**);
- Visual impact (in this case scoped out due to location of BMP);
- Traffic (**Section 14**).

In order to assess the potential social and community impacts, we have developed a suite of applicable social health and change indicators that will be used to assess the social impact of the BMP. These indicators are

- Demands on social infrastructure;
- In-migration/social cohesion;
- Acquisition of private property;
- Economic development/employment; and
- Communicable diseases.

The BMP development will be considered against these indicators to assess its impact on each.

18.3.2 Identification of Potentially Affected Communities

Those communities that may be potentially most directly affected by the BMP are the communities located to the north of the existing Refinery and BMP site: Ma'ameer, Nuwaidrat, Al Eker, East Riffa and Sanad. There are also permanent worker accommodation blocks to the south and west of the proposed BMP site.

With regard to Sitra Tank Farm, the communities at the southern end of Sitra Island may be affected, particularly Wadiyan and Abu Alayash. There are no communities close to Sitra Wharf.

Beyond these local communities, no further specific locations are considered in this assessment, other than the remainder of Bahrain as a general receptor of social and economic change.

18.3.3 Determination of Impact Significance

Impact significance has been determined by considering a combination of following factors:

- **Magnitude** of the impact;
- **Sensitivity** of the receptor;
- **Extent** of the impact; and
- **Duration** of the impact.

For the purpose of the assessment, these indicators have been assessed on a 5 point scale, with 1 being of low impact and 5 being a high impact. In each case, the values assigned can either be positive (+) indicating a beneficial impact, or negative (-) indicating an adverse impact. Values of zero / in the region of zero are considered to have a negligible impact.

To calculate the level of significance, an additive formula has been used as highlighted in **Table 18.2** to generate a numerical Impact Score.

Table 18.2 Impact Significance Calculation Matrix

[+/- value 1-5 **Magnitude**]	[+/- value 1-5 **Sensitivity**]
[+/- value 1-5 **Extent**]	[+/- value 1-5 **Duration**]
Impact Score= [**Magnitude**] + [**Sensitivity**] + [**Extent**] + [**Duration**]	

Once the Impact Score has been generated, the significance of the effect has been determined as highlighted in **Table 18.3**.

Table 18.3 Impact Significance

Impact Score Range	Impact Classification
-20 to -16	Major adverse impact
-15 to –11	Moderate adverse impact
-10 to -6	Minor adverse impact
-5 to 5	Negligible
6 to 10	Minor beneficial impact
11 to 15	Moderate beneficial impact
16 to 20	Major beneficial impact

18.4 Baseline

18.4.1 Kingdom of Bahrain

Bahrain is one of the most densely populated countries in the world, with an average density of 898 people per km^2 in the year 2000, which increased to 1660 persons per km^2 in the year 2010. Most of the population of the Kingdom is concentrated within the northern one-third of the country and specifically along the north and northeastern coastal areas of the main islands of Bahrain and Muharraq. Ninety percent of its population were living in urban centers in the year 2010, and this was projected to increase to more than 96% by year 2030 (Bahrain Census 2010 – BCIO (2016)).

The Kingdom of Bahrain has experienced rapid population growth over the last five decades with an annual national population growth rate of 3.6% per year during the period 1981-1991. The last population census (2010) shows that the total population of the Kingdom has increased from 650,172 (62% Bahrainis and 38% non-Bahrainis) in 2001 to 1,234,571 (46% Bahrainis and 54% non-Bahrainis) in the year 2010 - an increase of 89% in the inter-census period. The average annual total population growth during 2001-2010 was 7.38% (3.82% for Bahrainis and 11.77% for non-Bahrainis). The rapid population growth in the Kingdom has been derived from two factors:

i. natural growth of the indigenous population as health and socio-economic conditions improve (higher fertility rates, and lower mortality rates), and

ii. the influx of large numbers of foreign workers as demand for skills increases.

It is expected that these trends will continue into the future.

Decades of high fertility rates have resulted in an ever-increasing number of young people forming what is known as the "Youth Bulge". This presents a number of challenges for the Kingdom including employment and job opportunities, education, services, food, water and housing.

The average life expectancy at birth in the Kingdom of Bahrain was 73.7 years in 2000, and 74.9 years in the year 2010. This has risen due to the advancement of health care and higher standards of living, with the average being for both sexes 76 years in 2011. The average literacy rate (both sexes expressed as percentage aged 15 years and above) was 85.5% in the year 2000, and 87.9% in the year 2005. However, in the year 2010 the average increased to 90%.

Although the economy of the Kingdom of Bahrain is one of the most diversified in the Gulf, the oil and gas sectors contributed more than 80% of the Kingdom's revenues during the last decade. The average real growth rate of its Gross Domestic Product (GDP) was 6.5% in 2007, while it was 5.5% in 2010, 2.2% in 2011 and 3.5% in 2012. The GDP per capita has steadily increased and it reached USD 20,475 in 2011. The main sectors that contribute to GDP are: industries including oil and gas (11% of GDP); manufacturing (12.4% of GDP); services including finance (30% of GDP), transport and communication (8.9%); real estate (8.9% of GDP) and government services (14.8% of GDP).

In tandem with the growth in population, the total land area of the Kingdom of Bahrain has been increasing since the 1970s through land reclamation. Coastal waters around many parts of Bahrain, particularly on the northern and eastern coast are shallow and lend themselves to reclamation for development. The Kingdom's total land area has increased from about 662 km^2 in 1975 to 710 km^2 in 2000, then to 741.4 km^2 in 2006 and to 762.32 km^2 in 2010.

The Kingdom of Bahrain is divided into four Governorates – Capital, Muharraq, Northern and Southern. All Bapco facilities within the BMP are located within the Southern Governorate.

18.4.2 Southern Governorate

Southern Governorate is the largest Governorate but has the lowest population. It is the least populated of the regions in Bahrain and the least economically productive, per capita. Much of the Southern Governorate is open space and undeveloped land. However, there are a number of important industrial sites within the area including Bapco, Alba, GPIC, Banagas (Bahrain natural gas purification and processing plant), Al Dur (integrated desalination and power plant), South Alba industrial area and the Bahrain oil and gas field.

The Bahrain oil and gas field occupies much of the centre of the island and residential areas occupy the coastal zone (Hamad Town, Zallaq on the west coast, Jaww and Askar on the east coast and the new development of Durrat Al Bahrain to the south).

The Southern Governorate also hosts important leisure and educational resources in the western area including Bahrain International Circuit, Bahrain University and equestrian facilities.

The total population living in the Southern Governorate was 101,456 (8.2% of the total population in Bahrain), in 2010. The population in the Governorate was reported to be 248,341 in 2013. The Governorate, like other parts of the Kingdom, is undergoing a population increase which has been achieved by high growth rates of the local Bahrainis (natural increase), and influx of expatriate foreign workers (immigration). With the planned socio-economic developments in the Governorate and increasing rates of urbanisation and urban growth, and the demand for workers, the total numbers of the Bahraini and non-Bahraini population is expected to continue to increase.

18.5 Assessment of Impacts

18.5.1 Demands on Social Infrastructure

During construction there will be a need to house, on average, 15,000 workers for a period of approximately four years. Labour camps will be constructed specifically to house these workers. There will be two camps to the south of the Pitch Ponds and Refinery and one to the west of Alba.

The labour camps will have a dedicated electricity supply and will, therefore, not overload the local electricity supply to the surrounding communities. Wastewater from the camps will be treated in on-site package sewage treatment plants, and they will also have their own water supplies.

Workers from the labour camps south of the Refinery site will travel to work on foot. Buses will transport workers from the off-site labour camp to the BMP site. There may be temporary local congestion at the start and end of working shifts on local roads as a result.

It is not expected that construction workers will generally have access to private cars. Hence, during their free time and on their days off, many may choose to use public transport to access shopping and leisure facilities in Manama which could lead to overcrowding on the local transport network. To address this issue, a sufficient private bus service will need to be provided to allow workers to enjoy their leisure time and to travel freely to obtain goods and services. It is not recommended that there should be any stops in local communities. Buses should transport workers to main commercial centres only.

During construction the labour camps will have their own medical facilities which will be capable of treating minor to moderate injuries and illnesses and will be sized to adequately service the workforce. Workers with injuries requiring hospitalization will need to be transferred to an appropriate facility within Bahrain. With a high level of health and safety management, it is not expected that major incidents requiring hospital services will be commonplace and there should not be a significant drain on the local health infrastructure.

Collectively, the identified mitigation measures should reduce potential impacts from moderate adverse to negligible.

During operation the impacts on social infrastructure will be negligible. The BMP will be designed with its own utilities, transport impacts will be limited and any additional burdens to hospitals and schools will also be dispersed across Bahrain.

18.5.2 In-Migration/Social Cohesion

As discussed previously, a large number of workers will be required for the construction of the BMP. There is a lack of skilled labour in the numbers required in Bahrain and so the majority of these workers will be brought in from outside the country. Bringing in such a large migrant workforce has the potential to impact social cohesion and the nature of local communities by introducing a new population element.

However, in this case, during the construction phase the workforce will be housed in dedicated labour camps and so will not be directly integrated into local communities, such as Ma'ameer, Nuwaidrat and East Riffa. Direct impacts on the communities should be negligible. Access by walking or public transport from the labour camp sites to these locations is very poor and private transport in not expected to be generally in use. In addition, the construction workforce will be provided with a range of opportunities for recreation during their rest periods and on their days off.

To further mitigate possible impacts on local communities, it is recommended a Code of Conduct is developed by Bapco to be adopted by all workers on the construction site and those resident in the labour accommodation in particular. The Code of Conduct would identify acceptable behaviours expected of construction workers and labour camp residents.

The number of workers required during operation represents less than 0.1% of the total population of Bahrain and as such their impact will not be significant.

18.5.3 Economic Development/Employment

The BMP will have a major beneficial impact on the development of the national economy. The new Refinery configuration post-BMP, would allow for higher throughput, improved product quality and ensure Bapco's continued competitiveness under a wide range of process and market scenarios.

In respect of construction, the BMP will also have positive impact on the local and national economy. Many of the construction jobs created will be for immigrant workers, but some of the construction workforce required for the project will be Bahraini. This would lead to a temporary minor beneficial impact due to the temporal nature of the construction works.

Positive influences on local economic development could derive from purchase of local construction materials, job opportunities within the new Refinery, and multiplier effects on local ancillary services such as local restaurants and shopping malls. Bapco should promote local access to project employment for both the construction and operation phases. To do this Bapco should work with contractors to recruit workers from local communities in particular.

18.5.4 Acquisition of Private Property

All the different elements of the BMP will be constructed on Bapco property or within government owned land and so there is no requirement to acquire private property. There will be no impact for this impact category.

18.5.5 Communicable Diseases

The issue of communicable diseases is twofold. Firstly there is the risk of transmission of communicable diseases to residents within local communities, and secondly there is a risk of disease transmission within labour camps from worker to worker.

As the workers will be housed in labour camps removed from local communities, the risk of transference of disease between the two is considered low. In addition, it is a legal requirement in Bahrain for all expatriate workers to receive a medical prior to commencing work. One reason for this is to prevent the spread of communicable diseases. Within the labour camps there is a greater risk of spreading disease due to the close living arrangements. This possibility will be mitigated by constructing and operating the labour camps in accordance with the guidelines identified in **Section 19**.

18.6 Mitigation

The main potential social and community impacts of the BMP are associated with the presence of a large migrant construction workforce and its possible impact on local communities. In this case, because of the relatively isolated locations of the proposed labour camps, the potential for members of the construction workforce to travel to or otherwise directly impact the local communities is limited, but may comprise a **moderate adverse impact** without the implementation of mitigation measures.

A number of mitigation measures have been identified to reduce the residual impacts to a **negligible** level. These include provision of adequate infrastructure at labour camps (utilities; recreation; transportation and medical facilities) and implementation of statutory medical checks for migrant workers. There should also be a Code of Conduct for construction workers that identifies acceptable behaviour.

The BMP will deliver significant beneficial economic impacts including the creation of employment and economic development. These can be maximized during construction through the employment of local people and purchasing materials from local supplies. Bapco should encourage contractors to use the local workforce and suppliers.

18.7 Monitoring

The labour accommodation and related services will need to be carefully designed and operated to ensure the accommodation and facilities are adequately sized and remain functional and attractive to the workers. Minimum standards for labour accommodation are specified in Bahrain law and promoted in IFC guidance (see **Section 19**). The CESMP will require that the implementation and maintenance of these requirements is monitored regularly during the construction period.

18.8 Summary

The predicted impacts, mitigation and residual impacts are summarized in **Table 18.4**.

18.9 References

(BCIO 2016) Bahrain Central Informatics Organisation, viewed 14th March 2016. http://www.cio.gov.bh/cio_eng/Stats_SubDetailed.aspx?subcatid=604

(IFC 2102) IFC Performance Standards on Environmental and Social Sustainability, 2012

Table 18.4 Summary of Social and Community Impacts

Impact	Phase	Without mitigation: Magnitude	Extent	Sensitivity	Duration	Impact Score	Pre-Mitigation Impact	Mitigation	With Mitigation: Magnitude	Extent	Sensitivity	Duration	Impact Score	Residual Impact
Social Infrastructure	Construction	-5	-2	-3	-2	-12	Moderate Adverse	Provision of labour camps with utilities; transportation; recreation and medical facilities.	0	0	-3	-2	-5	Negligible
	Operation	0	0	0	-5	-5	Negligible	No specific measures required.	0	0	0	-5	-5	Negligible
In-Migration / Social Cohesion	Construction	-3	-3	-3	-2	-11	Moderate Adverse	Provision of labour camp, transportation to main shopping centres and entertainment centres. Development of a Code of Conduct for construction workers.	-0	-0	-3	-2	-8	Minor Adverse
	Operation	0	0	0	-5	-5	Negligible	No specific measures required.	0	0	0	-5	-5	Negligible
Economic Development/ Employment	Construction	+1	+1	+2	+2	+6	Minor Beneficial	Promote employment of local labour and sourcing of local materials through contractors.	+3	+3	+2	+2	+10	Moderate Beneficial
	Operation	+5	+4	+4	+5	+18	Major Beneficial	Promote employment of local labour.	+5	+5	+5	+5	+20	Major Beneficial
Acquisition of Private Property	Construction	0	0	0	0	0	No impact		0	0	0	0	0	None
	Operation	0	0	0	0	0	No impact		0	0	0	0	0	None
Communicable Diseases	Construction	-3	-2	-3	-2	-12	Moderate Adverse	Statutory pre-employment medicals, medical facilities.	0	0	-3	-2	-5	Negligible
	Operation	-1	-1	-1	-5	-8	Minor Adverse	Statutory pre-employment medicals, access to health care for employees.	0	0	0	-5	-5	Negligible

19 LABOUR AND WORKING CONDITIONS

19.1 Introduction

The construction and operation of the BMP will require a large labour force. Specifically during construction up to 15,000 workers will be employed. These will mainly be employed by contractors and sub-contractors. In addition the project will employ numerous suppliers most of which will be based outside Bahrain. During operation it is expected that the BMP will create approximately 600 permanent direct employees and sub-contract operations and maintenance workers.

This section addresses the requirements for the management of directly employed workers, main contractors, sub-contractors and the employees of suppliers to meet reasonable, fair and equitable employment conditions.

The societal impacts of direct and indirect employment during construction and operation of the project are addressed in **Section 18**, Community and Social Impacts. Furthermore, issues relating to occupational health and safety are addressed in **Section 20**.

19.2 Legislation and Guidance

19.2.1 National Legislation

19.2.1.1 Labour Law

Law No. 36 of 2012, the Promulgation of the Labour Law in the Private Sector and associated legislation sets out employment requirements for Bahraini nationals and migrant workers.

The law sets out employees rights with respect to conditions of employment such as: annual leave, maternity leave, sick leave entitlement, labour disputes resolution and other topics. It also sets out measures to prevent human trafficking and prohibition of discrimination practices such as discrimination in the payment of wages based on sex, ethnic origin, language, religion or beliefs.

19.2.1.2 Order No. 79 of 2009 Respecting the Procedures of Foreign Worker Transfer to Another Employer

This Order from the Ministry of Labour grants the right of foreign workers to transfer to work with another employer without obtaining consent of the existing employer, without prejudice to the rights of the worker. A worker can leave employment should he/she is not paid.

19.2.1.3 Workers' Accommodation

Ministerial Order No.40 of 2014 with respect to the requirements and specifications of workers' accommodation sets out minimum standards for labour accommodation including:

- space requirements;

- health and safety;
- kitchen facilities;
- dining facilities; and
- maintenance requirements.

19.2.2 International Guidance

19.2.2.1 International Finance Corporation Performance Standard 2 (IFC PS2) Labour and Working Conditions (IFC, 2012)

IFC PS2 sets out requirements for labour and working conditions. The key objectives of IFC PS2 are:

- To promote the fair treatment, non-discrimination, and equal opportunity of workers;
- To establish, maintain, and improve the worker-management relationship;
- To promote compliance with national employment and labour laws;
- To protect workers, including vulnerable categories of workers such as children, migrant workers, workers engaged by third parties, and workers in the client's supply chain;
- To promote safe and healthy working conditions, and the health of workers; and
- To avoid the use of forced labor.

19.2.2.2 Acceptable Standards and Management of Workers' Accommodation

Workers' Accommodation: Processes and Standards, 2009 has been developed jointly by IFC and the European Bank of Reconstruction and Development (EBRD) (IFC & EBRD, 2009) and provides guidance on the establishment and management of workers accommodation. The guidance covers the following topics:

- General living facilities (e.g. drainage, heating, ventilation, lighting, water, sanitation, waste disposal);
- Room/dormitory facilities;
- Ablution facilities;
- Canteen, cooking and laundry facilities;
- Food safety and nutritional standards;
- Medical facilities;
- Leisure, social and telecommunication facilities;
- Management of the accommodation;
- Community relations and consultation;
- Fees and charges for the facilities and services;
- Health and safety onsite;
- Accommodation and local community security;
- Workers' rights, rules and regulations; and
- Workers' consultation and grievance mechanism.

19.2.3 Assessment Methodology

In this instance there is no baseline for the assessment other than Bahraini employment law as it applies to current Bapco employees. Also the main impact to be considered will be during the construction period when main contractors and sub-contractors will be responsible for employing large numbers of largely migrant workers. Therefore, this assessment is based on a review of the applicable laws and guidance and identification of mitigation and management measures to be adopted during the construction and operational phases to ensure the BMP complies with relevant laws and guidance.

The classification of impact significance used in this assessment is qualitative. Where there is a requirement to adopt a measure to meet legal obligations then a minor, moderate or major adverse impact has been selected, depending on the likelihood and consequences of any non-compliance in the absence of mitigation. Where suitable mitigation and management measures are identified that would lead to routine compliance, then the residual impact has been assessed as negligible.

19.3 Impact Assessment

19.3.1 BMP Workforce

19.3.1.1 Construction Workforce

BMP construction will take approximately 4 years to complete and will require up to 15,000 workers at its peak. The majority of these will be migrant workers who will be housed in labour camps built specifically for the BMP.

It is envisaged that the BMP will be divided into three areas and that each area will be managed by one of three main contractors. Each main contractor will be responsible for a Work Package which will include management of their own labour and labour accommodation. Each main contractor is expected to employ a range of sub-contractors to provide specialist services. The accommodation for sub-contractors will be provided by the main contractors. The labour accommodation requirements will be specified by Bapco. The locations of the labour camp areas are shown in **Figure 2.10**.

19.3.1.2 Operations Workforce

Operation will require the employment of approximately 600 staff as direct employees of Bapco or as contractors. These staff will be employed in accordance with Bahraini law and, in the main, will source their own accommodation.

19.3.2 Comparison of Bahrain Labour Law and International Guidance

Table 19.1 presents a comparison of Bahrain law and international guidance with respect to labour law. The information presented is an overview of the main legal points and is not intended to be a legal interpretation of the law. The comparison presented indicates that there are some gaps between Bahrain law and IFC PS2. These gaps are in the areas of:

- Human resources policy and procedures;
- Grievance mechanism;
- Workers engaged by third parties;
- Management of supply chain.

In all other respects, existing Bahrain law appears to be sufficient to implement IFC requirements on labour and working conditions.

Table 19.1 Comparison of Bahrain Labour Law and IFC PS2

Summary of PS2 Provision	Key Points of Bahrain Law
Human Resources Policy and Procedures The client will adopt and implement human resources policies and procedures appropriate to its size and workforce that set out its approach to managing workers consistent with the requirements of this Performance Standard and national law. The client will provide workers with documented information that is clear and understandable, regarding their rights under national labour and employment law and any applicable collective agreements, including their rights related to hours of work, wages, overtime, compensation and benefits upon beginning the working relationship and when any material changes occur.	No provisions in Bahrain Law.
Working Conditions and Terms of Employment Where the client is a party to a collective bargaining agreement with a workers' organisation, such agreement will be respected. Where such agreements do not exist, or do not address working conditions and terms of employment, the client will provide reasonable working conditions and terms of employment. The client will identify migrant workers and ensure that they are engaged on substantially equivalent terms and conditions to non-migrant workers carrying out similar work. Where accommodation services are provided to workers covered by the scope of this PS, the client will put in place and implement policies on the quality and management of the accommodation and provision of basic services. The accommodation services will be provided in a manner consistent with the principles of non-discrimination and equal opportunity. Workers' accommodation arrangements should not restrict workers' freedom of movement or of association.	*Labour Law 2012, Article 19* States that the employment contract should include the terms of employment agreed by the parties, and may be entered into for a fixed term, or for an indefinite duration, which can be terminated on notice, or for execution of a specific project. The contract should be in writing in both English and Arabic and both parties should be given a copy. *Labour Law 2012, Article 39* Discrimination in wages based on sex, origin, language, religion or ideology shall be prohibited. *Ministerial Order No.40 of 2014 with respect to the requirements and specifications of workers' accommodation* Sets out minimum physical requirements for accommodation.
Workers' Organisation In countries where national law recognises workers' rights to form and to join workers'	*Workers Trade Union Law, 2002* This recognises the right of workers to organise collectively without discrimination in

Summary of PS2 Provision	Key Points of Bahrain Law
organisations of their choosing without interference and to bargain collectively, the client will comply with national law. Where national law substantially restricts workers' organisations, the client will not restrict workers from developing alternative mechanisms to express their grievances and protect their rights regarding working conditions and terms of employment. The client should not seek to influence or control these mechanisms. In either case described above, and where national law is silent, the client will not discourage workers from electing worker representatives, forming or joining workers' organisations of their choosing, or from bargaining collectively, and will not discriminate or retaliate against workers who participate, or seek to participate, in such organisations and collective bargaining. The client will engage with such workers' representatives and workers' organisations, and provide them with information needed for meaningful negotiation in a timely manner. Workers' organisations are expected to fairly represent the workers in the workforce.	employment. Article 10 states that: 'the workers of any establishment, of any particular sector, of any particular activity or of similar or associate industries or professions may establish their own trade union subject to the provision of this law'. Article 11 concerns the procedure for the formation of a trade union and states: 'The procedure for the formation of a trade union shall be by submitting to the Ministry its Constitution and the names of the founding members, provided that the Constitution shall not conflict with the provisions of the applicable laws and regulations in the Kingdom'.
Non-Discrimination and Equal Opportunity The client will not make employment decisions on the basis of personal characteristics[68] unrelated to inherent job requirements. The client will base the employment relationship on the principle of equal opportunity and fair treatment, and will not discriminate with respect to any aspects of the employment relationship, such as recruitment and hiring, compensation (including wages and benefits), working conditions and terms of employment, access to training, job assignment, promotion, termination of employment or retirement, and disciplinary practices. The client will take measures to prevent and address harassment, intimidation, and/or exploitation, especially in regard to women. Te principles of non-discrimination apply to migrant workers. In countries where national law provides for non-discrimination in employment, the client will comply with national law. When national laws are silent on non-discrimination in	*Labour Law 2012, Wages - Article 39* Discrimination in wages based on sex, origin, language, religion or ideology shall be prohibited.

[68] Such as gender, race, nationality, ethnic, social and indigenous origin, religion or belief, disability, age or sexual orientation.

Summary of PS2 Provision	Key Points of Bahrain Law
employment, the client will meet this Performance Standard. In circumstances where national law is inconsistent with this Performance Standard, the client is encouraged to carry out its operations consistent with the intent of the above without contravening applicable laws. Special measures of protection or assistance to remedy past discrimination or selection for a particular job based on the inherent requirements of the job will not be deemed as discrimination, provided they are consistent with national law.	
Retrenchment Prior to implementing any collective dismissals, the client will carry out an analysis of alternatives to retrenchment. If the analysis does not identify viable alternatives to retrenchment, a retrenchment plan will be developed and implemented to reduce the adverse impacts of retrenchment on workers. The retrenchment plan will be based on the principle of non-discrimination and will reflect the client's consultation with workers, their organisations, and, where appropriate, the government, and comply with collective bargaining agreements if they exist. The client will comply will all legal and contractual requirements related to notification of public authorities, and provision of information to, and consultation with workers and their organisations. The client should ensure that all workers receive notice of dismissal and severance payments mandated by law and collective agreements in a timely manner. All outstanding back pay and social security benefits and pension contributions and benefits will be paid (i) on or before termination of the working relationship to the workers, (ii) where appropriate, for the benefit of the workers, or (iii) payment will be made in accordance with a timeline agreed through a collective agreement. Where payments are made for the benefit of workers, workers will be provided with evidence of such payments.	*Labour Law 2012, Article 101* States that the worker shall be entitled to compensation for termination by the employer unless the termination of the contract is for a legitimate reason. The burden of proof of the legitimacy of termination of the contract shall be borne by the employer. *Labour Law 2012, Article 111* Determines what compensation employees are entitled to under different circumstances of dismissal by the employer.
Grievance Mechanism The client will provide a grievance mechanism for workers (and their organisations, where they exist) to raise workplace concerns. The client will inform the workers of the	No specific provisions in Bahrain law.

Summary of PS2 Provision	Key Points of Bahrain Law
grievance mechanism at the time of recruitment and make it easily accessible to them. The mechanism should involve an appropriate level of management and address concerns promptly, using an understandable and transparent process that provides timely feedback to those concerned, without any retribution. The mechanism should not impede access to other judicial or administrative remedies that might be available under the law or through existing arbitration or substitute for grievance mechanisms provided through collective agreements.	
Child Labour The client will not employ children in any manner that is economically exploitative, or is likely to be hazardous to or interfere with the child's education, or to be harmful to the child's health or physical, mental, spiritual, moral or social development. The client will identify the presence of all persons under the age of 18. Where national laws have provisions for the employment of minors, the client will follow those laws applicable to the client. Children under the age of 18 will not be employed in hazardous work. All work of persons under the age of 18 will be subject to an appropriate risk assessment and regular monitoring of health, working conditions and hours of work.	*Labour Law 2012, Employment of Minors, Articles 23 - 28* It is prohibited to employ any minor who is not yet 15. Minors should not be employed for more than 6 hours a day. They should be given one or more breaks, the total of which should not be less than 1 hour for a rest and a meal. They should not work more than 4 consecutive hours. They should not be employed at night or on weekly rest days or official holidays. Prior to appointment, the employer must verify: • the custodian or guardian approve the minor's employment; • the minor has undergone a medical examination to determine his physical fitness; • the minor is not engaged in hazardous work; • the Ministry is notified of al data related to the minor. Following the employment of the minor, an employer shall: • post in an apparent location the provisions on the employment of minors; • draft a statement clarifying the names of minors working, their age, the works entrusted to them and the date of their employment; • subject the minor to a periodic medical examination to verify his physical fitness.
Forced Labour The client will not employ forced labour, which consists of any work or service not voluntarily performed that is exacted form an individual under threat of force or penalty. This covers any kind of involuntary or compulsory labour, bonded labour, or similar labour-contracting arrangements. The client will not employ trafficked persons.	*Order No. 79 of 2009 Respecting the Procedures of Foreign Worker Transfer to Another Employer, Article 2* This states that a foreign worker has the right to transfer to work with another employer without obtaining consent of the existing employer, without prejudice to the rights of the worker. A worker can leave employment should he/she is not paid.
Occupational Health and Safety The client will provide a safe and healthy work environment, taking into account inherent	*Labour Law 2012, Title VX Occupational Safety and Health and Working Environment, Article 166*

Summary of PS2 Provision	Key Points of Bahrain Law
risks in its particular sector and specific classes of hazards in the client's work areas, including physical, chemical, biological, and radiological hazards, and specific threats to women. The client will take steps to prevent accidents, injury, and disease arising from, associated with, or occurring in the course of work by minimising, as far as reasonably practicable, the causes of hazards. In a manner consistent with GIIP, as reflected in various internationally recognised sources including the World Bank Group EHS Guidelines, the client will address areas that include the (i) identification of potential hazards to workers, particularly those that may be life-threatening, (ii) provision of preventative and protective measures, including modification, substitution, or elimination of hazardous conditions or substances, (iii) training or workers, (iv) documentation and reporting of occupational accidents, diseases, and incidents, and (v) emergency prevention, preparedness, and response arrangements. For additional information related to emergency preparedness and response to Performance Standard 1.	The employer must provide a safe and healthy work environment and take measures to protect workers from the following hazards: • mechanical hazards arising as a result of a collision or contact between the worker's body and a solid object; • hazards arising from handling solid, liquid or gas chemical substances or arising from the leakage of such substances to the working environment; • Natural hazards affecting the worker's safety and health as a result of a natural hazard or damage such as heat, humidity, cold, noise, dangerous and harmful radiations, quakes or the high or low atmospheric pressure in the workplace; • Hazards arising from the unavailability of means of safety, rescue, first aid and hygiene or the like and hazards arising from nutrition in cases where the employer is bound by virtue of the law to provide nutrition; • Fire hazards and hazards arising from electricity and lighting. Employers should prepare emergency plans which are tested to ascertain the adequacy and workers are trained in executing them. Employers should also inform workers' of potential hazards, provide them with free protective equipment and train them in its use.
Workers Engaged by Third Parties With respect to contracted workers the client will take commercially reasonable efforts to ascertain that the third parties who engage these workers are reputable and legitimate enterprises and have an appropriate ESMS that will allow them to operate in a manner consistent with the requirements of this Performance Standard (apartment from retrenchment & supply chain requirements). The client will establish policies and procedures for managing and monitoring the performance of such third party employers in relation to the requirements of this Performance Standard. In addition, the client will use commercially reasonable efforts to incorporate these requirements in contractual agreements with such third party employers.	No specific provisions in Bahrain Law.

Summary of PS2 Provision	Key Points of Bahrain Law
The client will ensure that contracted workers have access to a grievance mechanism. In cases where the third party is not able to provide a grievance mechanism, the client will extend its own grievance mechanism to serve workers engaged by the third party.	
Supply Chain Where there is a high risk of child labour or forced labour in the primary supply chain, the client will identify those risks consistent with the above requirements. If child labour or forced labour cases are identified, the client will take appropriate steps to remedy them. The client will monitor its primary supply chain on an ongoing basis in order to identify any significant changes in its supply chain and if new risks or incidents of child and/or forced labour are identified, the client will take appropriate steps to remedy them. Additionally, where there is a high risk of significant safety issues related to supply chain workers, the client will introduce procedures and mitigation measures to ensure that primary suppliers within the supply chain are taking steps to prevent or to correct life-threatening situations. The ability of the client to fully address these risks will depend upon the client's level of management control or influence over its primary suppliers. Where remedy is not possible, the client will shift the project's primary supply chain over time to suppliers that can demonstrate that they are complying with this Performance Standard.	No specific provisions in Bahrain law.

19.3.2.1 Human Resource Policy and Procedures

In respect of construction workers, it is recommended that Bapco prepares specific employment policy and procedures to be implemented on the project to ensure it is compliant with Bahraini law and IFC requirements. The requirements should be applicable to BMP direct employees, main contractors and sub-contractors.

Bapco should ensure that all direct employees, contractor and sub-contractor employees are provided with a clear and understandable written statement of their rights under national labour and employment law, and any applicable collective agreements including their rights to hours of work, wages, overtime, compensation and benefits upon beginning the working relationship and when any material changes occur.

Compliance with this document should be audited annually as part of the auditing required under the project Environmental and Social Management Plans.

19.3.2.2 Grievance Mechanism

All workers, and migrant workers in particular, should have access to grievance mechanisms that allow them to voice concerns without fear of punishment or retribution. Bapco will develop a specific workers' grievance mechanism for the project to provide a transparent and easily accessible way for workers to raise and address grievances. The mechanism should include procedures for the following:

- Registering the grievance;
- Screening and assessing the complaint;
- Formulating a response and settling the issue;
- Evaluate and monitor the results; and
- Sharing results for the purpose of 'lessons learnt'.

19.3.2.3 Workers Engaged by Third Parties

Bapco should ensure that all third parties (sub-contractors) comply with the requirements of the project human resource policy and procedures and CESMP, and that workers have access to a grievance mechanism.

Bapco should monitor/audit the performance of the third party employers to establish compliance with the aforementioned documentation.

19.3.2.4 Supply Chain

PS2 specifically extends its labour requirements on the employment of forced or child labour to the supply chain. Bapco should adopt procedures for investigation and monitoring of the supply chain to include the following:

- Mapping of the project supply chain to include Tier 1 (vendor and direct suppliers), Tier 2 (companies supplying Tier 1) and Tier 3 suppliers (companies supplying Tier 2);
- Conducting a risk assessment of all mapped suppliers to identify any issues with the employment of child or forced labour;

- Where there is a high risk of issues, Bapco should introduce procedures and mitigation measures to ensure that the suppliers are taking steps to prevent or correct these issues. Guidance can be found in "*Measure & Improve Your Labour Standards Performance", IFC & Social Accountability International (SAI)*; and
- Monitor the supply chain on an ongoing basis.

19.3.3 Comparison of Bahrain Labour Accommodation Law and International Guidance

Bahrain law regarding the specification of labour accommodation provides a limited number of minimum facility design standards which are in line with the recommendations made in IFC/ EBRD guidance. Generally the IFC/ EBRD guidance is more detailed. It also includes additional requirements in respect of canteens, security, leisure and medical facilities, workers' rights, consultation and grievance mechanisms and management of community relations.

19.3.3.1 Requirement for Labour Camps

The requirement for labour camps at or close to the project site has been identified as an integral part of the BMP FEED design. As nearly all the construction workers are expected to be immigrant labour, the development of project-specific labour camps provides a good means of minimizing the impact of the influx of persons on the local area and facilities. The locations of the labour camps are relatively isolated and there will be no simple or easy means of transportation to the immediate local areas. Also the labour camps will be developed as self-contained communities with a wide range of leisure and community support facilities to minimize the need for workers to travel to the surrounding areas to obtain goods and services.

19.3.3.2 Labour Camp Design

No detailed design specification for the labour accommodation is available at this stage of the project. It is recommended that the relevant Bahrain law and IFC/EBRD guidance form part of the design specification for the camps. The contractor's design should be audited for compliance with legal and guidance requirements prior to construction.

To minimise the impact on the local community, the labour camp will need to include a full range of community services including:

i. A full medical facility to include: a doctor's surgery, emergency facilities and dental care.
ii. Places of worship.
iii. A range of sports and leisure facilities including indoor and outdoor facilities.
iv. Shops and banking facilities.
v. Internet and telecommunications.
vi. Organized transportation to allow workers to leave the camp. A bus service to Manama centre and major shopping centres would be sufficient. This would be particularly important on Fridays which will be generally non-working days.

19.3.3.3 Labour Camp Operations

Bahraini law and IFC/ EBRD guidance identify the need to maintain labour accommodation during its use.

It is recommended that, as part of the CESMP, the labour camps are audited prior to occupation; 2 months following occupation and then every 6 months during their use until the end of construction.

19.4 Summary

Table 19.2 shows a summary of the potential impacts and identified mitigation and monitoring requirements.

19.5 References

(IFC, 2012) International Finance Corporation Performance Standard 2 (IFC PS2) Labour and Working Conditions

(IFC & EBRD 2009) Workers' Accommodation: Processes and Standards, IFC and EBRD, 2009.

Table 19.2 Summary of Impacts for Labour and Working Conditions

Issue / Impact	Potential Significance (Minor/Moderate/Major) (Beneficial/Adverse/Negligible)	Mitigation / Monitoring / Enhancement Measures	Residual Impacts (Slightly/Moderate/Major) (Beneficial/Adverse/Negligible)
Construction			
Human Resources policy and procedures	Minor Adverse Impact (Not establishing HR policy and procedures to comply with IFC PS2 requirements and specifically providing each employee with a clear statement of their employment rights).	Establishing HR policy and procedures for BMP in compliance with IFC PS2 requirements, including provision of a clear and understandable written statement of rights to each employee. Applicable to employees of all contractors and suppliers. Auditing of documents annually.	Negligible
Grievance mechanism	Minor Adverse Impact	Establishment of a grievance mechanism for employees of all contractors and suppliers. Auditing of documents annually.	Negligible
Use of forced and child labour	Major Adverse	Ensuring all procurement contracts contain clauses banning child and forced labour. Procurement to undertake a risk assessment to identify any high risk sub-contractors or suppliers. Auditing of documents annually.	Negligible
Labour camp design	Major Adverse	Ensure labour camp is designed according to Bahraini law and IFC guidance. Audit design compliance prior to construction.	Negligible

Issue / Impact	Potential Significance (Minor/Moderate/Major) (Beneficial/Adverse/Negligible)	Mitigation / Monitoring / Enhancement Measures	Residual Impacts (Slightly/Moderate/Major) (Beneficial/Adverse/Negligible)
Labour camp operations	Major Adverse	Auditing of labour camp operations to ensure that it is well maintained and suitable for use. Audit 2 months following occupation and then every 6 months during their use until the end of construction.	Negligible
Operations			
Human Resources policy and procedures	Minor Adverse Impact (Not establishing HR policy and procedures to comply with IFC PS 2 requirements and specifically providing each employee with a clear statement of their employment rights).	Establishing HR policy and procedures for BMP in compliance with IFC PS2 requirements, including provision of a clear and understandable written statement of rights to each employee. Applicable to employees of all contractors and suppliers. Auditing of documents.	Negligible

20 OCCUPATIONAL HEALTH AND SAFETY

20.1 Introduction

The nature of any large scale construction and/or industrial operation is such that personnel will be exposed to the risk of injuries and it is the duty of the employer to ensure that working conditions are safe and such risks are minimised.

This section discusses the potential occupational health and safety hazards associated with the BMP and provides an overview of the control and mitigation measures that will be put in place. For descriptive purposes, health and safety aspects have been grouped according to the type of activity, i.e. site preparation and mobilisation, construction, commissioning, operation, emergency situations and decommissioning / demolition. Labour accommodation requirements are addressed in **Section 19**. This section is not a comprehensive health and safety assessment or health and safety plan for the project. It provides an overview of key health and safety issues and management requirements.

Key risks which require to be managed are associated with the site preparation on the pitch ponds site due to the presence of residual pitch, risks associated with the handling of hazardous materials, risks associated with the commissioning and operational phases in terms of leaks and/or fire and explosions, plus working with heavy plant and under hot climatic conditions.

20.2 Legislation and Guidance

20.2.1 International

20.2.1.1 World Bank General Environmental Health and Safety (EHS) Guidelines, 2007: 2. Occupational Health and Safety (World Bank, 2007a)

These guidelines require that employers and supervisors are obliged to implement all reasonable precautions to protect the health and safety of workers. They provide guidance and examples of reasonable precautions to implement in managing principal risks to occupational health and safety during construction, operation and decommissioning.

The guidelines also identify that companies should hire contractors that have the technical capability to manage the occupational health and safety issues of their employees, extending the application of the hazard management activities through formal procurement agreements.

The guidance also provides a hierarchy of preventative and protective measures to eliminate hazards according to the following order of priority:

- Eliminating the hazard by removing the activity from the work process.
- Controlling the hazard at its source through use of engineering controls.
- Minimising the hazard through design of safe work systems and administrative or institutional control measures.
- Providing appropriate personal protective equipment (PPE) in conjunction with training, use and maintenance of the PPE.

Furthermore, the guidelines state that the application of prevention and control measures to occupational hazards should be based on comprehensive job safety or job hazard analyses.

20.2.1.2 World Bank EHS Guidelines for Crude Oil and Petroleum Product Terminals, 2007 (World Bank 2007b)

These guidelines are relevant to land and shore-based petroleum storage terminals receiving and dispatching bulk shipments of a wide variety of products.

The guidelines summarise the EHS issues associated with crude oil and petroleum product terminals that occur during the operation phases of a facility, along with recommendations for their management. They also identify occupational health and safety issues associated with crude oil and petroleum product terminals and provide measures to minimise the risk of incident.

The guidance also states that facilities should prepare an emergency preparedness and response plan that considers the role of communities and community infrastructure as appropriate.

Lastly the Guidelines provide advice on the monitoring requirements both in terms of environmental monitoring and occupational health and safety.

20.2.1.3 World Bank EHS Guidelines for Petroleum Refining, 2007 (World Bank, 2007c)

These guidelines cover processing operations from crude oil to finished liquid products. Similarly to the guidance above, the guidelines summarise the EHS issues associated with petroleum refining that occur during the operation phase, along with recommendations for their management.

The guidelines also state that facility-specific occupational health and safety issues should be identified based on job safety analysis or comprehensive hazard or risk assessment, using established methodologies such as a hazard identification study (HAZID), hazard operability study (HAZOP), or a quantitative risk assessment (QRA).

With regard to community health and safety, the guidance states that the most significant safety hazards are related to the handling and storage of liquid and gaseous substances. Impacts may include significant exposures to workers and, potentially, to surrounding communities, depending on the quantities and types of accidentally released chemicals and the conditions for reactive or catastrophic events, such as fire and explosion.

The guidance also provides a list of minimum elements that should be included in a Process Safety Management Program, as follows:

- Facility wide risk analysis, including a detailed consequence analysis for events with a likelihood above 10^{-6}/year, e.g. HAZOP, HAZID or QRA;
- Employee training on operational hazards;
- procedures for management of change in operations, process hazard analysis, maintenance of mechanical integrity, pre-start review, hot work permits, and other essential aspects of process safety included in General EHS Guidelines;

- Safe Transportation Management System as noted in the General EHS Guidelines of the project includes a transportation component for raw or processed materials;
- Procedures for handling and storage of hazardous materials;
- Emergency planning which should include, as a minimum, the preparation and implementation of an Emergency Management Plan, prepared with the participation of local authorities and potentially affected communities.

Performance indicators and requirements for monitoring are also suggested.

20.2.1.4 International Labour Organization (ILO) C155 - Occupational Safety and Health Convention, 1981 (ILO, 1981)

The convention places general requirements on businesses to adopt good practice measures in respect of H&S and to develop and maintain systems of communication between the employer and workforce in respect of H&S matters. Amongst other things the convention requires employers to ensure as far as reasonably practicable that they provide a safe environment for employees to work in and to provide H&S training and PPE to employees.

In Bahrain the convention is implemented by - Law No (25) of 2009 with respect to approving the accession of the kingdom of Bahrain to the international labour convention no. (155) of 1981 with respect to occupational safety and health, and work environment.

20.2.2 National

Occupational health and safety matters in Bahrain are regulated by the SCE's Directorate of Environmental Assessment and Control and by the Ministry of Labor and Social Development in conjunction with the Ministry of Health.

Relevant health and safety legislation in Bahrain is covered within key documentation as follows:

- Ministerial Order No. 1 of 1977 Respecting the Definition and Organisation of Primary Health Care for Workers in Establishments Employing More Than 50 Workers and subsequent amendments.
- Ministerial Order No. (3) of 2005 with Respect to Environmental Regulations and Standards in the Work Place.
- Ministerial Order No. 8 of 2013 with Respect to Regulating Occupational Safety and Health in Establishments.
- Ministerial Order No. 6 of 2013 with respect to Protection of Workers from the Hazards of Fire in Establishments and Work Sites.

Additional legislation is provided on specific health and safety issues:

- Ministerial Order No 4 of 1996 regarding Maintenance of Thermal Insulators which Contain Asbestos Material and Disposal Thereof.
- Ministerial Order No 4 of 1999 regarding Licensing Work in Maintaining Equipment and Buildings that Contain Asbestos, Removal and Transportation of this Material and Disposal of its Waste.

- Ministerial Order No 3 of 2013 with respect to Banning Work during Noon Time.
- Ministerial Order No 12 of 2013 with respect to Procedures Required to Report Occupational Injuries and Diseases.
- Ministerial Order No 4 of 2014 with respect to Determining the Required Conditions and Precautionary Measures for the Protection of Workers Engaged in Building Works, Construction and Civil Engineering.
- Ministerial Order No 5 of 2014 with respect to Determining the Required Conditions and Precautionary Measures for the Protection of Workers from the Hazards of Work on Lifting Equipment.
- Ministerial Order No.9 of 2014 with respect to Protecting Workers from Natural (physical) Hazards at Establishments and Worksites.
- Ministerial Order No.15 of 2014 with respect to Protecting Workers from the Hazards of Highly Flammable Liquids and Liquefied Petroleum Gases at Establishments and Worksites.
- Minister Order No 28 of 2014 with respect to Determining the Services and Conditions Required for the Protection of Workers from the Hazards of Boilers, Steam Recovery Tanks and Air Receiver Tanks.
- Ministerial Order No 38 of 2014 with respect to Determining the Required Conditions and Precautionary Measures for the Protection of Workers from Mechanical and Environmental Hazards.

These set out the legal requirements and specify actions and considerations that are required to be addressed in the workplace.

With respect to the construction, commissioning and decommissioning phases, the contractors and sub-contractors on-site must also adhere to the Labour Law for the Private Sector 2012 and legislation relating thereto, and the legal duties on the employer and contractors must be complied with.

20.3 Assessment Methodology

A qualitative health and safety assessment has been carried out on the likely activities during site preparation/mobilization, construction, commissioning, operation and decommissioning / demolition

Likely hazards and risks, mitigation measures to be implemented and the residual impacts of these activities are presented in the following sections. A summary of the main H&S risks is provided together with the means by which Bapco and their contractors intend to manage and mitigate these issues.

The following characteristics (**Table 20.1**) have been used to attribute significance to potential impacts to health and safety from the proposed development.

Table 20.1 Criteria for Impact Significance for Occupational Health and Safety

Impact Significance	Impact Characteristic
Major Adverse	Accident or incident resulting in loss of life or major injury.
Moderate Adverse	Accident or incident resulting in operational lost time and /or off site treatment of personnel is required.
Minor Adverse	Minor accident or incident.

20.4 Baseline

The BMP will be constructed immediately to the south of the existing Refinery on the pitch ponds site, although additional storage tanks are required within the Refinery. The existing Refinery to Sitra transfer lines crossing the Ma'ameer Channel will be substituted with newly designed pipelines and a new tank will be constructed within the existing Sitra Tank Farm. There will also need to be a change of service of some of the existing tanks. Three new LPG refrigerated tanks will be installed on land to the north of Sitra Wharf and new loading arms will be installed on the wharf itself. New sealines will also be required along with a change of service to some existing sealines. Many locations within the Refinery, Sitra Tank Farm and at the Pitch Ponds have been impacted by soil and groundwater contamination.

The Bapco Refinery is a mature facility and it operates a formal, documented health and safety management system that is certified to OHSAS BS 18001:2007 international standard for health and safety management.

Some buildings and equipment at the Refinery include asbestos containing materials (ACMs). The Refinery has previously been surveyed by Bapco and ACMs were identified both as lagging within equipment and as building materials within structures at the site. The majority of ACMs have been previously been removed by specialist contractors. The location and extent of the remaining ACMs is recorded in an asbestos register which forms part of an asbestos management plan (see **Appendix 20A**).

20.5 Assessment of Impacts

Throughout the project's lifetime from site preparation to operation, the workforce will be exposed to a number of different hazards and associated risks by the nature of the activities that are required for a project of this scale. If no risk controls or ineffective risk controls are implemented, injuries and fatalities could possibly occur during the site preparation and construction process, and injuries could also occur during the inspection and maintenance activities that are necessary during operation.

The following sections discuss the risks associated with the main stages of the project, i.e. site preparation and mobilisation, construction, commissioning and operation.

20.5.1 Site Preparation and Mobilisation

Prior to construction, there will be a requirement to change the levels of parts of the site to provide an even surface for construction and provide suitable drainage gradients to allow gravity drainage in sewers and pipes. In particular the Pitch Ponds will be raised by an average of approximately 3m. During mobilization, site roads will be prepared, labour camps and site stores (including fuel storage) created and package sewage treatment plants installed and commissioned. There will also be a need for power and water supplies to be installed. The labour camps will have sleeping accommodation, ablution facilities, medical facilities, recreation facilities, canteen facilities and laundry facilities. The mobilisation activities will involve the movement of plant and equipment, working with construction chemicals, manual handling, excavation, welding, grinding, electrical, mechanical and plumbing, lifting and potential to work at height or in confined spaces. The impacts associated with these activities are summarised in **Table 20.2**.

Table 20.2 Occupational Health and Safety Impacts during Site Preparation and Mobilisation

Description of Impact	Risk of occupational health and safety hazards on site (e.g. contaminated soil, accidents, injury, falling, falling equipment, hot-work, electrical exposure, confined spaces, heat stress during summer).
Receptor(s)	Site workers.
Features of Impact	Local, avoidable risk but impact could be long-term or permanent (or could even result in death) if safety measures are breached; very high sensitivity of receptor, national legislation relating to occupational health and safety including Ministerial Orders 8 of 2013 and No. 3 of 2005.
Significance of Impact	**Minor to Moderate Adverse** depending on type of accident/injury, and nature/magnitude of soil contamination, **Major Adverse** significance if serious accidents or fatalities occur.
Mitigation Advice	• Training and awareness of workers regarding occupational safety issues on site. • Provision of safety facilities, emergency equipment, and first aid facilities together with personnel trained in its use. • Provide Personal Protective Equipment (PPE) as appropriate for tasks undertaken. • Ensure the contractor specification adequately covers the assessment of risk of their employees for all construction activities, such as in a Construction Code of Practice (e.g. dealing with potentially contaminated soil onsite). • Continuous provision of drinks and sheltered/shaded areas for labourers , especially during the summer months to avoid heat stress.
Residual Impact	**Negligible impact.** Robust management and control of all aspects of health and safety, including appropriate training for staff and contractors, during the construction activities should provide a safe working environment.

20.5.2 Construction

20.5.2.1 Introduction

There are five main sites where construction activities will be taking place for the BMP and these are: the Pitch Ponds site, the existing Refinery, the pipe bridge across Ma'ameer Channel, Sitra Tank Farm and Sitra Wharf (including new sea lines). Due to the varying nature of these five sites, a wide range of occupational health and safety risks exist, although there are some overlaps in the issues likely to be faced by construction workers.

There are common general activities associated with each construction site such as the storage and delivery of fuels for onsite generators and plant, storage and delivery of chemicals and other materials, storage and delivery of water for site and personnel use and removal of wastewaters and wastes. These activities will involve moving of plant and vehicles, unloading of potentially hazardous materials and manual handling. The impacts associated with general activities are presented in **Table 20.3** and **Sections 6** to **19** discuss any specific requirements of the different construction sites, such as working with contaminated land and working in or near water.

Furthermore, construction workers are at risk of injury as a result of fire, explosion and/or release of toxic gases from the existing Refinery process units. Working in close proximity to existing process units will need to be managed carefully and will be covered in the Emergency Response Plan.

Table 20.3 Occupational Health and Safety Impacts Associated with General Construction Activities

Description of Impact	Risk of occupational health and safety hazards on site (e.g. contaminated soil, accidents, injury, falling, falling equipment, hot-work, electrical exposure, confined spaces, heat stress during summer). Risk of injury from working in close proximity to existing process units.
Receptor(s)	Site workers.
Features of Impact	Local, avoidable risk but impact could be long-term or permanent (or could even result in death) if safety measures are breached; very high sensitivity of receptor, national legislation relating to occupational health and safety including Ministerial Orders 8 of 2013 and No. 3 of 2005.
Significance of Impact	**Minor to Moderate Adverse** depending on type of accident/injury, and nature/magnitude of soil contamination, **Major Adverse** significance if serious accidents or fatalities occur.
Mitigation Advice	• Training and awareness of workers regarding occupational safety issues on site. • Provision of safety facilities, emergency equipment, and first aid facilities together with personnel trained in its use. • Provide Personal Protective Equipment (PPE) as appropriate for tasks undertaken. • Ensure the contractor specification adequately covers the assessment of risk of their employees for all construction

	activities, such as in a Construction Code of Practice (e.g. safe use of vehicles on construction sites). • Continuous provision of drinks and sheltered/shaded areas for labourers , especially during the summer months to avoid heat stress. • Preparation of Emergency Response Plan to cover working in close proximity to existing process units.
Residual Impact	**Negligible impact.** Robust management and control of all aspects of health and safety, including appropriate training for staff and contractors, during the construction activities should provide a safe working environment.

20.5.2.2 Pitch Ponds Site

Specific to the Pitch Ponds site is the fact that residual pitch exists. During construction an average of approximately 3m of clean fill material will be placed on top of the Pitch Ponds and consequently workers will not be routinely exposed to pitch. Impacts relating to the residual pitch will only be relevant during piling activities when soil containing pitch is brought to the surface. The piling contractor should undertake a risk assessment prior to commencing work in order to establish safe working practices and a safe disposal method for any contaminated material. The impact specific to the Pitch Ponds site is summarised in **Table 20.4**.

Table 20.4 Occupational Health and Safety Impacts Specific to the Pitch Ponds Site during Construction

Description of Impact	Risk of exposure to contaminated soil.
Receptor(s)	Site workers.
Features of Impact	Short-term, acute health effects, local, avoidable risk, very high sensitivity of receptor, national legislation relating to occupational health and safety including Ministerial Orders 8 of 2013 and No. 3 of 2005, international guidance regarding working on contaminated sites.
Significance of Impact	**Minor to Moderate Adverse** - dependent on the nature of contamination and length of exposure.
Mitigation Advice	• Training and awareness of workers regarding occupational safety issues on site. • Provision of safety facilities, emergency equipment, and first aid facilities together with personnel trained in its use. • Provide Personal Protective Equipment (PPE) as appropriate for tasks undertaken. • The piling contractor should undertake a risk assessment to establish safe working practices and a safe disposal method for any contaminated material.
Residual Impact	**Negligible impact.** Robust management and control of all aspects of health and safety, including appropriate training for staff and contractors, during the construction activities should provide a safe working environment.

20.5.2.3 Refinery and Sitra Tank Farm

Specific to the Refinery and Sitra Tank Farm sites, similar to the Pitch Ponds site during construction, is the potential for workers to encounter contaminated soil and to be exposed to volatile hydrocarbon vapours during excavation and piling work.

Prior to site preparation, a risk assessment should be undertaken to identify the risks to site workers. As a minimum, all site workers should be provided with appropriate PPE. A hygiene area should be created for site workers exposed to contaminated soil or water so that they can change out of any contaminated clothes and shower prior to leaving site. Vapour monitoring should be provided for H_2S and VOCs during groundworks. No food should be permitted on the site, only drinking water. The potential impacts are described in **Table 20.5**.

Table 20.5 Occupational Health and Safety Impacts Specific to the Refinery and Sitra Tank Farm during Construction

Description of Impact	Risk of exposure to contaminated soil and vapours.
Receptor(s)	Site workers.
Features of Impact	Short-term exposure, acute health effects, local, very high sensitivity of receptor, national legislation relating to occupational health and safety including Ministerial Orders 8 of 2013 and No. 3 of 2005, international guidance regarding working on contaminated sites.
Significance of Impact	**Minor to Moderate Adverse** depending on the nature of the contaminant and length of exposure.
Mitigation Advice	• Training and awareness of workers regarding occupational safety issues on site; • Provision of safety facilities, emergency equipment, and first aid facilities together with personnel trained in its use; • Provide Personal Protective Equipment (PPE) as appropriate for tasks undertaken; • Ensure the contractor specification adequately covers the assessment of risk of their employees for all construction activities, such as in a Construction Code of Practice (e.g. dealing with potentially contaminated soil onsite), • Provision of a hygiene area; and • Monitoring for vapours including H_2S and VOCs during groundworks.
Residual Impact	**Negligible impact.** Robust management and control of all aspects of health and safety, including appropriate training for staff and contractors, during the construction activities should provide a safe working environment.

20.5.2.4 Ma'ameer Channel and Sitra Wharf

Within the Ma'ameer Channel a new pipe bridge will be constructed to the immediate south of the existing one. The construction will involve the creation of one or more temporary working platforms from which to construct the pipe bridge.

Environment Arabia

Three new LPG tanks will be installed on land to the north of Sitra Wharf and some modifications to the existing Wharf facilities will be required, including the provision of 19 new loading arms and new slop facilities. New pipelines will be constructed in the marine environment.

For work to be performed near water, it is recommended that sufficient barricades are erected close to the water's edge to serve as an early warning system when a worker unintentionally approaches the edge. A risk assessment should be undertaken to determine the need for workers to wear flotation devices. Rescue equipment must be available on site such as 'pole and life hook' and 'ring buoy'; staff must be trained in their use. Training should be provided to all workers on the use of flotation devices.

For marine construction activities involving diving, the following should be required:

- Production of a diving risk assessment;
- Diver medical qualifications; all divers must have medical fitness for diving;
- Diver Training and Certification; all divers should be trained and certified;
- Procedures for emergency care; prior to each dive, supervisors must assure that location-specific emergency care procedures are in place and understood by each diver. These procedures must include at a minimum, procedures for recompressions and evacuation.

These will be achieved by adherence to Bapco's diving procedures and Permit to Work requirements.

Potential impacts specific to the Ma'ameer Channel and Sitra Wharf are presented in **Table 20.6**.

Table 20.6 Occupational Health and Safety Impacts Specific to the Ma'ameer Channel and Sitra Wharf during Construction

Description of Impact	Risk of injury from falling into water and death resulting from drowning. Risks associated with diving work.
Receptor(s)	Site workers.
Features of Impact	Temporary for injury, permanent if death results from drowning, local, very high sensitivity of receptor, national legislation relating to occupational health and safety including Ministerial Orders 8 of 2013 and No. 3 of 2005, international guidance regarding working on contaminated sites.US OSHA Standard No. 1926.106.
Significance of Impact	**Minor to Moderate Adverse** for injury, **Major Adverse** if drowning results in death.
Mitigation Advice	• Training and awareness of workers regarding occupational safety issues on site. • Provision of life-saving equipment, e.g. flotation devices, life buoys, life hooks) together with personnel trained in its use. • Provision of first aid facilities together with personnel trained in its use. • Ensure the contractor specification adequately covers the assessment of risk of their employees for all construction activities following guidance such as OSHA Working over or near water.

	• Adherence to Bapco procedures and Permit to Work requirements for diving work.
Residual Impact	**Negligible impact.** Robust management and control of all aspects of health and safety, including appropriate training for staff and contractors, during the construction activities should provide a safe working environment.

20.5.3 Commissioning

The commissioning process will involve undertaking tests on the BMP prior to it going into operation in order to determine that it will function adequately and safely. The commissioning process will include training the people who will operate the BMP as well as the management team, and the production of adequate operating instructions.
During commissioning, when operating experience is at a minimum, there is the possibility of unforeseen events occurring. Consequently, all safety precautions, including the Emergency Plan, should be reviewed prior to commissioning commencing.

During commissioning there is a risk of explosion, fire, release of hazardous chemicals or substances, and burns and scalds. The commissioning team should be made fully aware of the potential hazards and be provided with appropriate PPE for their individual tasks.

Potential impacts during commissioning and suggested mitigation is summarised in **Table 20.7**.

Table 20.7 Occupational Health and Safety Impacts during Commissioning

Description of Impact	Risk of injury resulting from fire, explosions, leaks during commissioning.
Receptor(s)	Site workers.
Features of Impact	Temporary for injury, permanent if death results, local, very high sensitivity of receptor, national legislation relating to occupational health and safety including Ministerial Orders 8 of 2013 and No. 3 of 2005, international guidance regarding working on contaminated sites.
Significance of Impact	**Minor to Moderate Adverse** for injury, **Major Adverse** if accident results in death.
Mitigation Advice	• Training and awareness of workers regarding occupational safety issues on site. • Provision of appropriate PPE. • Provision of first aid facilities together with personnel trained in its use. • Ensure the contractor specification adequately covers the assessment of risk of their employees for all commissioning activities.
Residual Impact	**Negligible impact.** Robust management and control of all aspects of health and safety, including appropriate training for staff and contractors, during commissioning should provide a safe working environment.

20.5.4 Operation

The plant and equipment at the BMP will be modern, largely automatic and totally enclosed. During operation, there will be approximately 600 employees which includes managers, engineers, technicians, laboratory staff and maintenance staff. There will be a requirement for routine inspection and scheduled maintenance (i.e. turnover and inspection (T&I)) during the operational phase. Routine operations of the refining processes generally present a low risk of exposure when adequate maintenance is carried out and proper industry standards for design, construction and operation have been followed. The potential for hazardous exposures for the workforce still exists, however.

The principal exposures to hazardous substances occur during shutdown or maintenance work, since these are a deviation from routine operations. T&I work will require careful planning, scheduling and step-by-step procedures to make sure that unanticipated exposures do not occur. Any plant shutdown requires a complete plan in writing to cover all activities, the impact on other operations, and emergency planning. **Table 20.8** presents the potential impacts and provides information on safe work practices and procedures that should be followed.

Table 20.8 Occupational Health and Safety Impacts during Operation

Description of Impact	Risk of injury resulting from fire, explosion, hazardous substances. Risk of inhalation of solvent vapours, toxic gases.
Receptor(s)	Site workers.
Features of Impact	Temporary for injury, permanent if death results, local, very high sensitivity of receptor, national legislation relating to occupational health and safety including Ministerial Orders 8 of 2013 and No. 3 of 2005, international guidance regarding working on contaminated sites.
Significance of Impact	**Minor to Moderate Adverse** for injury, **Major Adverse** if accident results in death.
Mitigation Advice	• Provide appropriate PPE, e.g. hearing protection, safety glasses, respiratory protection, protective (non-flammable) clothing, rubber boots. • Prepare H&S risk assessments for all activities. • Operate a permit-to-work system. • Operate a vehicle permit system. • Training and awareness of workers regarding occupational safety issues on site. • Provision of first aid facilities together with personnel trained in its use.
Residual Impact	**Negligible impact.** Robust management and control of all aspects of health and safety, including appropriate training for staff and contractors, during operation should provide a safe working environment.

20.5.5 Emergency Situations

20.5.5.1.1 Major Accident Hazards Assessment

As part of the BMP design, the FEED engineer – Technip, has undertaken an Accident Consequence Analysis (Technip, 2016), a quantitative risk assessment of possible major accident hazard scenarios e.g. explosions, fires. The hazard scenarios considered were based on the output of BMP Hazard and Operability (HAZOP) studies and expert judgement. These studies showed that there are no significant risks to sensitive off-site receptors associated with potential major incidents. In respect of on-site risks from major incidents, the BMP has been designed with respect to the conclusions of the Accident Consequence Analysis. As such the site layout has been designed to minimise as far as practicable, the consequences of major incidents.

Table 20.9 presents the potential H&S impacts of major accident hazards and identifies the mitigation and management measures required to achieve safe design, operation and maintenance.

Table 20.9 Major Accident Hazards Potential Impacts and Mitigation

Description of Impact	Risk of major accident hazards – fire, explosion, release of toxic vapours
Receptor(s)	Site workers, site neighbours
Features of Impact	Highly unlikely but has potential for significant loss of life, significant environmental damage, significant economic damage
Significance of Impact	**Moderate Adverse to Major Adverse** depending on the scale of the type and scale of the incident.
Mitigation Advice	General measures would include: • General safety in design practice studies; • Operating and maintaining the equipment in accordance with operation and maintenance manuals and approved procedures; • Working to a formal H&S management system; • Implementation of an Emergency Response Plan and Oil Spill Contingency Plan.
Residual Impact	**Negligible impact.** Inclusion of specific identified design requirements and adoption of good practice measures in design and operation should make major accidents extremely unlikely and limit their impact should an incident occur.

20.5.5.1.2 Crisis and Emergency Response Plan

Bapco have in place a Crisis and Emergency Response Plan (CERP) (Bapco, 2015) to ensure the company provides a co-ordinated, proportionate and rapid response in emergency situations. In order of priority, the CERP is designed to achieve:

- safety and security of people;
- protection of the environment;

- protection of assets; and
- protection of reputation.

The CERP identifies three levels of emergency scenario that are outlined in **Table 20.10**. The level of response is dependent on the level of the emergency scenario. The Level 3 response requires co-ordination with government and external agencies including civil defence (fire service) and medical services but the systems of integration are already in place for the existing Bapco facilities and the BMP will not place a greater day to day demand on these services.

Table 20.10 Levels of Emergency Response

Level	Description
Level 1	An incident which can be dealt with by the facility or location personnel and resources. The incident does not have any effect outside the facility/location with limited external involvement. There is minimal risk to life, to the environment, Company assets or reputation.
Level 2	An incident which may be dealt with locally but requires support from Bapco central organisation and may involve external resources and agencies. The incident may be 'on-site', have some effect outside the site or be 'off-site'. There is possible risk to life, environment, assets or reputation.
Level 3	An incident, which requires the use of wide-ranging resources and/or government and external agencies: The incident will have technical, media, external affairs and personnel implications which require immediate assistance from the Crisis Management Team. There will be at least one of the following: ▪ death and/or serious injuries; ▪ potential for significant pollution or environmental damage; ▪ substantial damage to property; ▪ damage to Bapco reputation.

The CERP has the following key sections:

- notifications and activations (in case of emergencies);
- emergency management organisation & responsibilities;
- incident management locations, facilities and equipment;
- linked plans & response forms (including major accident hazard analysis reports and oil spill contingency plan);
- CERP plan maintenance, response training and exercises.

As part of the BMP project development, the CERP will need to be reviewed to ensure it includes any additional requirements introduced by the BMP. **Table 20.11** summarise the potential impacts and mitigation required.

Table 20.11 BMP Major Accident Hazards Impacts and Mitigation

Description of Impact	Major incident hazards – fire, explosion, release of toxic vapours
Receptor(s)	Site workers, site neighbours
Features of Impact	Highly unlikely but has potential for significant loss of life, significant environmental damage, significant economic damage
Significance of Impact	**Minor Adverse to Major Adverse** depending on the scale of the type and scale of the incident.
Mitigation Advice	Review of the Crisis Emergency Response Plan to include for the BMP so that the measures to limit the impact of incidents are in place.
Residual Impact	**Negligible impact.** Inclusion of the BMP within the CERP will ensure that the impact of any incidents is minimized.

20.5.5.2 Oil Spill Contingency Plan

Bapco have in place an Oil Spill Contingency Plan (OSCP) (OSRL, 2013) to ensure the company provides a co-ordinated, timely and appropriate response to oil spills. The plan covers all Bapco assets in Bahrain that refine, transport or store oil or oil products and marketing fuel stations. This includes the Refinery, the transfer lines to Sitra, Sitra Tank Farm and Sitra Wharf.

The plan allows for four different response levels to tailor the response to the seriousness of the situation. The OSCP response levels are shown in **Table 20.10**.

Table 20.12 Oil Spill Response Levels Identified in OSCP

Tier	Volumes		
Minor	<25 bbls	<4 m³	<4 tonnes
Tier 1	25 - 375 bbls	4 - 60 m³	4 - 60 tonnes
Tier 2	375 - 7500 bbls	60 - 1190 m³	60 - 1250 tonnes
Tier 3	>7500 bbls	>1190 m³	>1250 tonnes

The plan includes a risk assessment to determine the possible spill scenarios applicable at each location so that the spill response equipment and spill response organization can be mobilized/deployed to contain and combat the spill.

Due to the expansion of the Refinery, revision to Sitra Wharf facilities and proposals to import MTBE, the BMP will change the risk profile of Bapco operations and the OSCP will require to be updated prior to commissioning new plant. In addition the construction of the NOGA terminal at Sitra, the development of East Sitra Housing and proposed changes to Sitra Wharf by ALBA, GPIC and Banagas may also change the risk profile and require the OSCP to be reviewed. **Table 20.13** summarises the requirements.

Table 20.13 BMP Oil Spill Response Impact and Mitigation

Description of Impact	Major incident hazards – Oil and Refinery product spills
Receptor(s)	Site workers, marine environment
Features of Impact	Highly unlikely but has potential for significant environmental damage, significant economic damage and possible loss of life

Significance of Impact	**Minor Adverse to Major Adverse** depending on the scale of the type and scale of the incident.
Mitigation Advice	Review of the Oil Spill Contingency Plan to include for the BMP and other developments in the vicinity of Bapco operations so that the measures to limit the impact of incidents are in place.
Residual Impact	**Negligible impact.** Inclusion of the BMP and other developments within the OSCP will ensure that the impact of any incidents is minimized.

20.5.6 Decommissioning and Demolition

Decommissioning and demolition of an industrial facility has similar potential occupational health and safety risks as the construction and commissioning phases. However there is a requirement for the preparation of a structural survey of equipment before it is demolished so that the work and sequenced in a safe are some additional requirements Decommissioning and demolition will also require the removal, treatment and/or disposal of hazardous substances and waste including ACMs.

Prior to the removal of residual ACMs, any buildings constructed prior to 1996 (the year asbestos was banned in Bahrain) should be given demolition type asbestos surveys (destructive surveys) to identify any additional ACMs not previously identified.

During decommissioning and demolition, workers would be exposed to hazardous substances, would be required to work in confined spaces and at height, and would have to operate machinery/tools and work with moving plant and equipment. The impacts associated with decommissioning and demolition are presented in **Table 20.14.**

Table 20.14 Occupational Health and Safety Impacts During Decommissioning and Demolition

Description of Impact	Risk of occupational health and safety hazards on site (e.g. contaminated soil, accidents, injury, falling, falling equipment, hot-work, electrical exposure, confined spaces, heat stress during summer).
Receptor(s)	Site workers.
Features of Impact	Local, avoidable risk but impact could be long-term or permanent (or could even result in death) if safety measures are breached; very high sensitivity of receptor, national legislation relating to occupational health and safety within Ministerial Order No. 3 of 2005 and 6 of 2000, and international standards such as WHO Standards for Worker & Occupational Health and the US Occupational Safety and Health Administration (OSHA) Standards.
Significance of Impact	**Minor to Moderate Adverse** depending on type of accident/injury, **Major Adverse** significance if serious accidents or fatalities occur.
Mitigation Advice	• Training and awareness of workers regarding occupational safety issues on site. • Provision of safety facilities, emergency equipment, and first aid facilities together with personnel trained in its use. • Provide Personal Protective Equipment (PPE) as

	appropriate for tasks undertaken. • Ensure the contractor specification adequately covers the assessment of risk of their employees for all decommissioning activities. • Continuous provision of drinks and sheltered/shaded areas for labourers , especially during the summer months to avoid heat stress. • Physically and electrically isolate equipment to be demolished. • Drain down lines, tanks and equipment, clean and vent tanks and equipment. • Demolition survey of pre-1996 buildings for ACMs (destructive survey). • Removal and disposal of asbestos by specialist contractors. • Undertaking a structural survey of equipment to be demolished and sequencing work to ensure the plant being demolished does not pose a risk of collapse.
Residual Impact	**Negligible impact.** Robust management and control of all aspects of health and safety, including appropriate training for staff and contractors, during the construction activities should provide a safe working environment.

20.6 Mitigation

20.6.1 General Requirements

In order to mitigate potential occupational health and safety risks, a formal H&S management system should be implemented including the following general requirements:

- Use of health and safety assessment of contractors and sub-contractors during pre-qualification and qualification stages to ensure they have the technical skills to manage H&S to the required standards. Inclusion of H&S management requirements into formal contract documents.
- Development of a H&S control plan (including method statements, standard operating procedures and risk assessments) outlining measures to enhance the safe loading, transportation and unloading of components and materials to site. These may include lift plans, working at height controls, etc.
- Speed limits and warning signs should be respected at all times on the local road network.
- All traffic should stay within road corridors and not stray into the open desert as the loads may become unstable in soft conditions (e.g. in labour camp areas).
- On busy roads, consideration should be given to the use of flag-men for vehicles with large loads entering the road network.
- Maintenance of roads should be implemented at all times to ensure that they are kept clear of any sand and debris that may obstruct easy access and safety.
- A permit to work system should be implemented for higher risk activities during the operations, e.g. hot work, working with electricity, working close to H_2S sources, mixing chemicals, working in confined spaces, etc.

- The Health and Safety Control Plan should also cover general aspects such as control of dusts including what to do during dust storms or high winds, working in hot conditions, working at night, lighting, noise and hearing controls, hygiene, etc.
- Emergency aspects such as spills and leaks, fire, rescue at height, from confined spaces or from storage pits, medical emergencies and vehicle accidents should also be covered.
- Induction training and awareness training of workers regarding occupational safety issues on-site.
- Provision of safety facilities.
- Provision of safety tools and clothing (i.e. PPE) such as hard hats, safety boots, eye protection, ear protectors, respiratory protection against emissions and fumes, gloves for handling certain types of materials and waste, etc.
- Provision of emergency response equipment such as first aid boxes (which need to be checked frequently), adequate water supply, and eye wash stations and emergency showers if appropriate.
- Correct storage and handling of hazardous materials.
- Continuous provision of drinks and sheltered/shaded areas for laborers, especially during the summer months to avoid heat stress.
- Supervisors should provide frequent breaks for employees, air conditioned refuges for breaks where practicable, and electrolyte solutions to maintain body chemistry in order to minimize the effects of heat stroke.

20.6.2 Construction

20.6.2.1 Pitch Ponds

Prior to commencing construction work within the Pitch Ponds site, the piling contractor should undertake a risk assessment to establish safe working practices and a safe disposal method for any contaminated material.

20.6.2.2 Refinery and Sitra Tank Farm

The following mitigation measures are specific to the Refinery and Sitra Tank Farm:

- Undertake a risk assessment prior to commencing work in order to establish safe working practices and a safe disposal method for any contaminated material.
- Provision of a hygiene area for workers who may be exposed to contaminated materials;
- Monitoring for vapours including H_2S and VOCs during groundworks.

20.6.2.3 Ma'ameer Channel and Sitra Wharf

The following mitigation measures are specific to Ma'ameer Channel and Sitra Wharf:

- Erect barricades close to the water's edge;
- Undertake a risk assessment to determine the need for worker's to wear flotation devices;
- Production of a diving risk assessment;
- Diver medical qualifications; all divers must have medical fitness for diving;
- Diver Training and Certification; all divers should be trained and certified; and

- Procedures for emergency care; prior to each dive, supervisors must assure that location-specific emergency care procedures are in place and understood by each diver. These procedures must include at a minimum, procedures for recompressions and evacuation.

20.6.3 Commissioning

The following mitigation measures are specific to the commissioning phase:

- Preparation of a H&S plan for commissioning activities including any emergency response requirements specific to commissioning.

20.6.4 Operation

The following mitigation measures are specific to the operational phase:

- Update the Crisis and Emergency Response Plan and OSCP to include for the BMP prior to commencing operations.
- Integrate BMP into Bapco H&S management systems.
- Implementation of a formal H&S management system.

20.6.5 Decommissioning and Demolition

Decommissioning and demolition require the following specific H&S management measures:

- Ensure isolation and electrical disconnection of plant;
- Draining down, venting and cleaning of equipment prior to demolition;
- Demolition survey of all pre-1996 buildings for additional ACMs;
- Removal of ACMs by specialist contractors;
- Undertaking a structural survey of equipment to be demolished and sequencing work to ensure the plant being demolished does not pose a risk of collapse.

20.7 Monitoring

The mitigation measures identified are included in the project CESMP and OESMP as appropriate. Adherence to the mitigation measures should be checked as part of the regular auditing of the implementation of the CESMP and OESMP.

20.8 Summary

Table 20.15 shows a summary of occupational health and safety issues for the BMP.

20.9 References

(Bapco, 2015) Crisis and Emergency Response Plan, Bapco Health, Safety and Environment Department Report ref. OEMS/FE/EMERG/EMER/4. Issue 1, October 2015.

(ILO, 1981) International Labour Organization (ILO) C155 - Occupational Safety and Health Convention, 1981

(OSRL, 2013) Bapco, Oil Spill Contingency Plan. Oil Spill Response Limited. Document No. OEMS/ENVIR/000/OIL/1, Issue 1.1, June 2015.

(Technip, 2016) Accident Consequence Analysis, Technip report No. 2520-z000-ML-203_Rev C, 2016.

(World Bank, 2007a) World Bank General Environmental Health and Safety (EHS) Guidelines, 2007: 2. Occupational Health and Safety

(World Bank 2007b) World Bank EHS Guidelines for Crude Oil and Petroleum Product Terminals, 2007

(World Bank, 2007c) World Bank EHS Guidelines for Petroleum Refining, 2007

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Table 20.15 Summary of Occupational Health and Safety Impacts

Impact/ Activity	Potential Significance (Minor/Moderate/Major) (Beneficial/Adverse/Negligible)	Mitigation / Monitoring / Enhancement Measures	Residual Impacts (Minor/Moderate/Major) (Beneficial/Adverse/Negligible)
General Construction Activities	Major - Minor	• Implementation of a formal H&S management system including: • Health and safety assessment of contractors and during pre-qualification and qualification stages. • Inclusion of H&S management requirements into formal contract documents. • Development of a H&S control plan (including method statements, standard operating procedures and risk assessments). • Speed limits and warning signs should be respected at all times on the local road network. • All traffic should stay within road corridors. • On busy roads, consideration should be given to the use of flag-men for vehicles with large loads entering the road network. • Maintenance of roads should be implemented at all times to ensure that they are kept clear of any sand and debris. • A permit to work system should be implemented for higher risk activities. • Induction training and awareness training of workers regarding occupational safety issues on-site.	Negligible

Impact/ Activity	Potential Significance (Minor/Moderate/Major) (Beneficial/Adverse/Negligible)	Mitigation / Monitoring / Enhancement Measures	Residual Impacts (Minor/Moderate/Major) (Beneficial/Adverse/Negligible)
		• Provision of safety facilities. • Provision of safety tools and clothing (i.e. PPE) such as hard hats, safety boots, eye protection, ear protectors, respiratory protection against emissions and fumes, gloves for handling certain types of materials and waste, etc. • Provision of emergency response equipment such as first aid boxes (which need to be checked frequently), adequate water supply, and eye wash stations and emergency showers if appropriate. • Correct storage and handling of hazardous materials. • Continuous provision of drinks and sheltered/shaded areas for laborers, especially during the summer months to avoid heat stress. • Supervisors should provide frequent breaks for employees, air conditioned refuges for breaks where practicable, and electrolyte solutions to maintain body chemistry in order to minimize the effects of heat stroke. • Emergency Response Plan for construction phase.	
Site Preparation and Mobilization	Major - Minor	• As per general construction activities	Negligible
Pitch Ponds Site – Exposure to contamination during construction	Moderate - Minor	• As per general construction activities • The piling contractor should undertake a risk	Negligible

Impact/ Activity	Potential Significance (Minor/Moderate/Major) (Beneficial/Adverse/Negligible)	Mitigation / Monitoring / Enhancement Measures	Residual Impacts (Minor/Moderate/Major) (Beneficial/Adverse/Negligible)
		assessment to establish safe working practices and a safe disposal method for any contaminated material.	
Refinery and Sitra Tank Farm Sites – Exposure to contamination during construction	Moderate - Minor	• As per general construction activities • Provision of a hygiene area • Monitoring for vapours including H2S and VOCs during groundworks.	Negligible
Ma'ameer Channel and Sitra Wharf	Major - Minor	• As per general construction activities • Provision of life-saving equipment, e.g. flotation devices, life buoys, life hooks) together with personnel trained in its use. • Contractor specification adequately covers the assessment of risk of their employees for all construction activities following guidance such as OSHA Working over or near water. • Adherence to Bapco procedures and Permit to Work requirements for diving work.	Negligible
Commissioning – General requirements	Major - Minor	• As per general construction activities • Ensure the contractor specification adequately covers the assessment of risks for commissioning activities.	Negligible
Operation – General requirements	Major - Minor	• Implementation of a formal H&S management system including: • Provide appropriate PPE, e.g. hearing protection, safety glasses, respiratory protection, protective	Negligible

Impact/ Activity	Potential Significance (Minor/Moderate/Major) (Beneficial/Adverse/Negligible)	Mitigation / Monitoring / Enhancement Measures	Residual Impacts (Minor/Moderate/Major) (Beneficial/Adverse/Negligible)
		(non-flammable) clothing, rubber boots. • Prepare H&S risk assessments for all activities. • Operate a permit-to-work system. • Operate a vehicle permit system. • Training and awareness of workers regarding occupational safety issues on site. • Provision of first aid facilities together with personnel trained in its use.	
Major Accident Hazard	Major - Moderate	• General safety in design practice studies; • Operating and maintaining the equipment in accordance with operation and maintenance manuals and approved procedures; • Working to a formal H&S management system; • Implementation of an Emergency Response Plan and Oil Spill Contingency Plan.	Negligible
Crisis and Emergency Response Plan	Major - Minor	• Review of the Crisis Emergency Response Plan to include for the BMP so that the measures to limit the impact of incidents are in place.	Negligible
Oil Spill Contingency Plan	Major - Minor	• Review of the Oil Spill Contingency Plan to include for the BMP and other developments in the vicinity of Bapco operations so that the measures to limit the impact of incidents are in place.	Negligible
Decommissioning and Demolition	Major - Minor	• As per general construction activities	Negligible

Impact/ Activity	Potential Significance (Minor/Moderate/Major) (Beneficial/Adverse/Negligible)	Mitigation / Monitoring / Enhancement Measures	Residual Impacts (Minor/Moderate/Major) (Beneficial/Adverse/Negligible)
		• Physically and electrically isolate equipment to be demolished. • Drain down lines, tanks and equipment, clean and vent tanks and equipment. • Demolition survey of pre-1996 buildings for ACMs (destructive survey). • Removal and disposal of asbestos by specialist contractors. • Undertaking a structural survey of equipment to be demolished and sequencing work to ensure the plant being demolished does not pose a risk of collapse.	

21 ENVIRONMENTAL MANAGEMENT AND MITIGATION

21.1 Project Phases

The ESIA process has undertaken an analysis of the environmental and social impacts that are predicted to arise from the BMP. Where adverse impacts have been identified, mitigation and management measures have been recommended to control and minimize them. In some cases mitigation will be achieved by design, and in other cases mitigation will take the form of on-going management actions to control emissions. To be effective, it is recommended that the mitigation measures identified in the ESIA are applied to the design, construction and operational phases of the project. Therefore, this section presents a summary of the ESIA findings split into: Design; Construction and Operation. Construction includes commissioning of new plant and decommissioning and demolition of existing plant that will be made redundant by the BMP.

21.2 Design Phase

The BMP design has been developed according to engineering standards and criteria adopting good engineering practices aimed at minimising environmental impacts. Nevertheless, a number of mitigation measures have been identified as a result of the ESIA to further reduce the expected environmental impact. All the mitigation measures identified as a result of the ESIA are summarised in **Table 22.1**.

The FEED stage for the BMP was undertaken alongside the ESIA and is now complete. It is expected that the BMP will be granted environmental permission by the SCE based on the design presented in this ESIA. In the next project phases the EPC contractor will be responsible for detailed engineering design of the BMP and its procurement and construction. During these stages it is possible that the design of the BMP may change and these changes may alter the environmental footprint of the project. If the environmental footprint of the project exceeds the conditions identified in this ESIA, it will be the responsibility of the EPC contractor to inform the SCE and obtain from them a direction as to whether the design changes are considered trivial or significant. If they are considered significant the SCE may request further assessment and evaluation of the environmental consequences of the design changes. It is the responsibility of the EPC contractor to determine that the design specification remains consistent with the ESIA throughout the remaining project phases.

If the design is changed the CESMP, OESMP and, if needed, the ESIA will need to be revised.

It is also important that the mitigation measures identified in this ESIA and the CESMP and OESMP are fully implemented. These documents will be included in the contract documentation for all contractors, sub-contractors and significant suppliers.

21.3 Construction Phase

Construction Phase mitigation measures are summarized in **Table 22.1**. This includes many separate packages of work: site preparation, construction (civil, mechanical, electrical, etc.), commissioning and decommissioning and demolition of redundant plant. There is a general set of mitigation and GIIP measures that will apply to all construction work, but also each package has specific mitigation requirements.

21.4 Operational Phase

Operational Phase mitigation measures are summarized in **Table 22.2**.

Bapco is a mature integrated oil and gas business and its day-to-day operations are managed by its own policies and procedures. Bapco's environmental management system (EMS) is accredited to ISO 14001 and its occupational health and safety management system is accredited to OHSAS 18001 to ensure that Bapco complies with internationally recognised standards. The BMP units will be operated by Bapco in accordance with these standards and the BMP will be assimilated into the Refinery management systems. Hence, the majority of the operational phase impacts focus on updating management plans and procedures to include the BMP.

During the operational phase the Refinery will also be required to continue with reporting initiatives such as compliance reporting to the SCE, banks and lenders environmental reporting, reporting of carbon emissions and on-going stakeholder engagement.

21.5 Summary of BMP Impact

The ESIA has determined that the BMP will not lead to any substantive environmental impacts that cannot be managed or mitigated.

Whilst there are numerous potential environmental impacts, the great majority can be rendered negligible. In some cases it has been assessed that there will be residual minor adverse impacts and these are identified in relevant ESIA sections and **Tables 22.1-22.3**.

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Table 21.1 Design Phase Management and Mitigation Requirements

Design Phase Impact	Impact Significance	Mitigation Summary	Residual Impact
General Requirements			
Inclusion of ESIA Mitigation and Management requirements into contracts.	N/A	• Relevant requirements of ESIA and CESMP should be provided to all construction / commissioning / decommissioning contractors and sub-contractors at bidding stage as part of contract specification.	N/A
Design specification.	N/A	• The design specification must remain consistent with the ESIA. If the environmental footprint exceeds the parameters given in the ESIA then agreement to the alterations must be obtained from the SCE.	N/A
Terrestrial Ecology			
Loss of feeding and roosting grounds for birds during construction - coastal fringe.	Minor Adverse	• Design mitigation has considered the layout of the construction compound to avoid the coastal fringe.	Minor Adverse
Cultural Heritage			
Impact during construction on sites of archaeological significance.	Negligible	• Design mitigation includes protection of areas of interest by providing fencing of three registered sites of archaeological significance prior to mobilisation.	Negligible
Chemicals			
Storage of MTBE at Sitra Tank Farm	Negligible	• Design mitigation includes provision of a secondary impermeable bund with a capacity of 110%, a bottom leak detection system and overfill alarms. • If existing tanks are not provided with such facilities, provision of new tanks shall be considered.	Negligible

Design Phase Impact	Impact Significance	Mitigation Summary	Residual Impact
Social and Community Impacts			
Social Infrastructure.	Moderate Adverse	• Provision of labour camps with utilities; transportation; recreation and medical facilities.	Negligible
Labour and Working Conditions			
Use of forced and child labour.	Major Adverse	• Ensuring all procurement contracts contain clauses banning child and forced labour. • Procurement to undertake a risk assessment to identify any high risk sub-contractors or suppliers.	Negligible
Labour camp design.	Major Adverse	• Ensure labour camp is designed according to Bahraini law and IFC guidance. • Audit design compliance prior to construction.	Negligible

Table 21.2 Construction Phase Management and Mitigation Requirements

Construction Phase Impact	Impact Significance	Mitigation Summary	Residual Impact
Air Quality			
Construction Phase Dust	Negligible	• Best practice dust mitigation measures implemented to minimise emissions.	None
Construction Vehicle Emissions	Negligible	• Establishment of lay down area and routine haul routes away from residential areas.	None
Soil and Groundwater			
Pitch Ponds - Presence of residual pitch on Pitch Ponds	Major Adverse	• Capping with approximately 3m of clean fill.	Major Beneficial
Pitch Ponds - Waste oil contaminated soil – no validation of earlier remediation	Minor Adverse	• Undertake remediation validation site investigation, remove any significant contamination found in the south west corner of the Pitch Ponds site.	Negligible
Pitch Ponds - Presence of LNAPL in BH1056 and dissolved hydrocarbon contamination in BH1060	Minor Adverse	• Develop a long term groundwater monitoring programme for the BMP site. Keep under review as part of that program.	Minor Adverse
Pitch Ponds / All BMP - VOC vapour intrusion BH1056 into built structures	Minor Adverse	• Incorporate impermeable vapour barrier into ground slab of buildings. Extended to all occupied BMP buildings as a precautionary measure.	Negligible
All BMP – Contaminated soils	N/A – Good practice guidance	• Keep contaminated pile arisings separate from clean soil. • Reuse or remediate contaminated soils within Bapco facilities.	N/A

Construction Phase Impact	Impact Significance	Mitigation Summary	Residual Impact
All BMP – Construction Workers, protection of health	N/A – Good practice guidance	• Implement good practice measures to reduce worker exposure to contaminant.	N/A
All BMP – Groundwater contamination	N/A – Good practice guidance	• Develop a long term groundwater monitoring programme for the BMP site.	N/A
All BMP sites – Update Contamination Assessment	N/A Good practice guidance	• Update the contamination assessment during the EPC phase as the BMP design develops	N/A
Noise and Vibration			
Construction Noise Day	Negligible to Minor Adverse	• Best Practicable Means regarding construction methodology and equipment. Major construction works will not take place in evening/night periods.	Negligible to Minor Adverse
Construction Noise Evening	Minor Adverse		Negligible to Minor Adverse
Construction Noise Night	Major Adverse		Negligible to Minor Adverse
Construction Vibration	Negligible	• None	Negligible
Marine Impacts			
Marine Sediment Loading and Resuspension – AOI 1, Farasiyah Bay	Negligible	• None	Negligible
Marine Sediment Loading and Resuspension – AOI 2, Ma'ameer Channel	Minor Adverse	• Use on clean fill with less than 10% fines for any temporary reclamation. • Consider deploying silt curtains north and south of work along the full	Negligible

Construction Phase Impact	Impact Significance	Mitigation Summary	Residual Impact
		width of the channel. • Excavated material from piling operations is not to be discharged back to the channel. • If there are any de-watering works required, the contractor is advised of the requirement to ensure that 'waste' water is first passed through a settlement tank(s); TSS of waters is not to exceed a monthly average of 20 mg/l or a single maximum event of 35 mg/l[69]. Ensure that settlement tanks are regularly inspected and that accumulated fines are removed and disposed at a suitable location. • TSS monitoring to requirements of EIA-9 Guidelines (SCE, 2010).	
Marine Sediment Loading and Resuspension – AOI 3, Sitra Wharf	Minor Adverse	• The contractor and appointed environment consultant to liaise with ALBA to further quantify the risks and confirm the necessary mitigation. This will require establishing TSS thresholds for the ALBA intake, development of a monitoring protocol and consideration of additional physical mitigation (i.e. installation of silt curtains around the intake). • Attempt to avoid trenching works; if this is unavoidable select methods that result in the least disturbance of seabed sediments (e.g. closed clam shell buckets) and ensure that excavated material is not dumped to sea. • Should covering of trenches be required, use suitable material with low fine content. Adhere to Deltares (2008) Land Reclamation	Minor Adverse

[69] These standards originate from the Bahrain Industrial Effluent Standards.

Construction Phase Impact	Impact Significance	Mitigation Summary	Residual Impact
		Manual. Ministry of Works. • Should trenching/backfilling take place, develop a TSS monitoring protocol, which addresses the thresholds of sensitive receptors (e.g. ALBA intake). Ensure monitoring is conducted as per the agreed protocol and ameliorate actions are in place prior to commencement should a breach occur.	
Spillages of Fuels, Chemicals and Wastes – AOI 1, Farasiyah Bay	Negligible	• None	Negligible
Spillages of Fuels, Chemicals and Wastes – AOI 2, Ma'ameer Channel	Minor Adverse	• Excavated material (from piling operations) is not to be dumped back to the channel but is to be disposed of appropriately on land. • Fuel stores to be kept away from the water's edge and stored appropriately (i.e. on an impermeable base and within a bund capable of holding 110% of the stored amount). • Do not wash tools/plant/equipment in the waters of the channel. • Ensure wash water from any concrete casting works do not percolate or are drained to the channel. • Ensure all equipment is well maintained and free from oil/fuel leaks, which could enter marine waters.	Negligible
Spillages of Fuels, Chemicals and Wastes – AOI 3, Sitra Wharf	Minor Adverse	• Ensure appropriate fuel/oil spill mitigation is in place and appropriate to the size of vessels employed.	Negligible
Marine Sediments - AOI 2, Ma'ameer Channel	Minor Adverse	• It is recommended that prior to commencement of works, that additional sediment samples be taken and analysed for organotins.	Negligible

Construction Phase Impact	Impact Significance	Mitigation Summary	Residual Impact
		Should elevated levels be detected, then a contaminated remediation plan and/or additional mitigation should be implemented.	
Terrestrial Ecology			
Loss of terrestrial habitat - coastal fringe	Negligible	• Ensure construction compound is securely fenced. • Good housekeeping and waste management to avoid windblown litter. • No discharge of wastewater to the marine environment. • Store all equipment within fence-line. • Vehicles to adhere to allocated access roads. • No workers to be permitted outside the fence-line.	Negligible
Loss of terrestrial habitat - site west of Alba	Negligible	• None required.	Negligible
Disturbance to feeding and roosting grounds for birds during construction - Ma'ameer Channel	Minor Adverse	• Consider 'soft start' for piling activities.	Minor Adverse
Loss of terrestrial habitat - Ma'ameer Channel	Negligible	• None required.	Negligible
Traffic and Access			
Site Preparation	Significant	• Improved access for BMP. • Transport oversized load by sea close to site as practicable.	Significant - Short periods of
Transport of Construction Workers	Significant		

Construction Phase Impact	Impact Significance	Mitigation Summary	Residual Impact
Transport of Oversized Loads	Significant	• Implement Traffic Management Plan (TMP).	increased congestion.
Construction Plant, Equipment and Materials	Not Significant	• Implement Traffic Management Plan (TMP).	Not Significant
Waste			
Construction and commissioning wastes	Minor to Moderate Adverse	• Implement a construction phase waste management plan. • Proactively manage waste. • Segregate waste at source to maximise recycling and reuse opportunities. • Manage waste responsibly - maintain Duty of Care.	Negligible Most waste streams can be minimised, reused or recycled. Only limited non-hazardous waste streams will require disposal.
Decommissioning wastes	Major to Minor Adverse	• Recycling or safe disposal of used catalysts. • On site waste treatment for hazardous wastes and disposal to off-site non-hazardous landfill. • Segregation and recycling of commercials wastes to maximise recycling.	Negligible
Chemicals			
Contractor to update chemicals risk assessment prior to	N/A	• N/A	N/A

Construction Phase Impact	Impact Significance	Mitigation Summary	Residual Impact
commencement of construction and then review and update it as needed.			
Storage of Fuels	Minor Adverse	• Store away from oxidizers. • Keep from heat, sparks, and open flames. • Store with MSDS. • Trained operatives and PPE. • Store quantities in excess of 200 litres (1 barrel) in a secondary impermeable bund with a capacity of 110% of the vessel. • Place smaller containers on drip trays. • All generators to be placed on metal drip trays of suitable size to retain spills and leaks. • Implement a spill response procedure. • Store spill response kits at all fuel storage locations. • Clean-up any minor spills by removing fuel stained soil and proper disposal. • No fuels to be stored within 10m of surface water features.	Negligible
Social and Community Impacts			
In-Migration / Social Cohesion	Moderate Adverse	• Provision of labour camp, transportation to main shopping centres and entertainment centres. • Development of a Code of Conduct for construction workers.	Minor Adverse

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Construction Phase Impact	Impact Significance	Mitigation Summary	Residual Impact
Economic Development/ Employment	Minor Beneficial	• Promote employment of local labour and sourcing of local materials through contractors.	Moderate Beneficial
Communicable Diseases	Moderate Adverse	• Statutory pre-employment medicals, medical facilities.	Negligible
Labour and Working Conditions			
Human Resources policy and procedures	Minor Adverse	• Establishing HR policy and procedures for BMP in compliance with IFC PS2 requirements, including provision of a clear and understandable written statement of rights to each employee. • Applicable to employees of all contractors and suppliers. • Auditing of documents annually.	Negligible
Grievance mechanism	Minor Adverse	• Establishment of a grievance mechanism for employees of all contractors and suppliers. • Auditing of documents annually.	Negligible
Use of forced and child labour	Major Adverse	Annual auditing of: • Procurement contract documents to ensure they contain clauses banning child and forced labour. • Procurement risk assessment to identify any high risk sub-contractors or suppliers.	Negligible
Labour camp operations	Major Adverse	• Auditing of labour camp operations to ensure that it is well maintained and suitable for use. • Audit 2 months following occupation and then every 6 months during their use until the end of construction.	Negligible

Construction Phase Impact	Impact Significance	Mitigation Summary	Residual Impact
Occupational Health and Safety			
General Construction Activities	Major – Minor Adverse	• Health and safety assessment of contractors and during pre-qualification and qualification stages. • Inclusion of H&S management requirements into formal contract documents. • Development of a H&S control plan (including method statements, standard operating procedures and risk assessments). • Speed limits and warning signs should be respected at all times on the local road network. • All traffic should stay within road corridors. • On busy roads, consideration should be given to the use of flag-men for vehicles with large loads entering the road network. • Maintenance of roads should be implemented at all times to ensure that they are kept clear of any sand and debris. • A permit to work system should be implemented for higher risk activities. • Induction training and awareness training of workers regarding occupational safety issues on-site. • Provision of safety facilities. • Provision of safety tools and clothing (i.e. PPE) such as hard hats, safety boots, eye protection, ear protectors, respiratory protection against emissions and fumes, gloves for handling certain types of	Negligible

Construction Phase Impact	Impact Significance	Mitigation Summary	Residual Impact
		materials and waste, etc. • Provision of emergency response equipment such as first aid boxes (which need to be checked frequently), adequate water supply, and eye wash stations and emergency showers if appropriate. • Correct storage and handling of hazardous materials. • Continuous provision of drinks and sheltered/shaded areas for laborers, especially during the summer months to avoid heat stress. • Supervisors should provide frequent breaks for employees, air conditioned refuges for breaks where practicable, and electrolyte solutions to maintain body chemistry in order to minimize the effects of heat stroke. • Emergency Response Plan for construction phase.	
Pitch Ponds Site – Exposure to contamination during construction	Moderate – Minor Adverse	• As per general construction activities. • The piling contractor should undertake a risk assessment to establish safe working practices and a safe disposal method for any contaminated material.	Negligible
Refinery and Sitra Tank Farm Sites – Exposure to contamination during construction	Moderate – Minor Adverse	• As per general construction activities. • Provision of a hygiene area. • Monitoring for vapours including H2S and VOCs during groundworks.	Negligible
Ma'ameer Channel and Sitra Wharf	Major – Minor Adverse	• As per general construction activities. • Provision of life-saving equipment, e.g. flotation devices, life buoys,	Negligible

Construction Phase Impact	Impact Significance	Mitigation Summary	Residual Impact
		life hooks) together with personnel trained in its use. • Contractor specification adequately covers the assessment of risk of their employees for all construction activities following guidance such as OSHA Working over or near water. • Adherence to Bapco procedures and Permit to Work requirements for diving work.	
Commissioning	Major – Minor Adverse	• As per general construction activities. • Ensure the contractor specification adequately covers the assessment of risks for commissioning activities.	Negligible
Decommissioning and Demolition	Major – Minor Adverse	• As per general construction activities. • Physically and electrically isolate equipment to be demolished. • Drain down lines, tanks and equipment, clean and vent tanks and equipment. • Demolition survey of pre-1996 buildings for ACMs (destructive survey). • Removal and disposal of asbestos by specialist contractors. • Undertaking a structural survey of equipment to be demolished and sequencing work to ensure the plant being demolished does not pose a risk of collapse.	Negligible

Table 21.3 Operational Phase Management and Mitigation Requirements

Operational Phase Impact	Impact Significance	Mitigation Summary	Residual Impact
Air Quality			
Direct (stack) Emissions	Negligible for NO_2, PM_{10} and CO Beneficial for SO_2 concentrations	• Stacks designed to allow adequate dispersion of pollutants into the atmosphere.	Periodic monitoring of existing sources and BMP processes. Maintain emissions inventory to ensure that emissions remain within designed limits. Residual impact remains negligible for NO_2, PM_{10} and CO and beneficial for SO_2
Fugitive/ Evaporative Emissions	Minor Adverse	• BMP processes designed in accordance with best practice to minimise losses.	Fugitive/ evaporative emissions minimised by adherence to site's existing environmental management/monitoring plan

Operational Phase Impact	Impact Significance	Mitigation Summary	Residual Impact
Greenhouse Gas Emissions	N/A – Good practice guidance	• Annual, public reporting of emissions required for Scope 1 and Scope 2 GHG emissions.	N/A
Soil and Groundwater			
All BMP – Groundwater contamination	N/A – Good practice guidance	• Groundwater monitoring. Develop and implement a groundwater monitoring plan.	N/A
Noise and Vibration			
Operational Plant/Machinery Noise	Negligible to Minor Adverse	• In case results of EPC noise study confirm a minor adverse effect on N4 and N5, mitigation measures should be applied.	Negligible to Minor Adverse
Marine Impacts			
Hydrodynamics and Water Quality – AOI 1 – Farasiyah Bay	Negligible	• Establish monitoring points for each point of discharge to the main and #6OWS channels; this will enable better control and understanding should effluents to sea show unexpected elevated levels of contaminants. • Establish a monitoring protocol for defined parameters, which facilitates the regular monitoring of effluents discharged to sea. An online system should be considered to enable constant data streams, which can then be linked to additional monitoring strategies (e.g. monitoring of marine waters and ecology).	Negligible
Terrestrial Ecology			
Impact of operational noise on feeding and roosting birds – coastal fringe	Minor Adverse	• Measures to reduce noise emissions from the BMP will be considered further during the EPC phase.	Minor Adverse
Waste			

Operational Phase Impact	Impact Significance	Mitigation Summary	Residual Impact
Operational wastes	Major to Minor Adverse	• Recycling of used catalysts. • On site waste treatment for hazardous wastes and disposal to off-site non-hazardous landfill. • Segregation and recycling of commercials wastes to maximise recycling. • Reporting waste quantities to SCE.	Negligible
Chemicals			
Contractor to provide a list of new chemicals and MSDS to be used in operations to SCE for approval.	N/A	N/A	N/A
New storage tanks to meet BAT (and Bahraini legal requirements).	Moderate to Major Adverse (depending on material to be stored.	• Use a secondary impermeable bund with a capacity of 110%. • Use leak detection system. • Overfill alarms.	Negligible
Process chemicals, cleaning chemicals and anti-scaling chemicals.	Minor to Moderate Adverse (depending on chemical).	• Use and storage of chemical in accordance with MSDS.	Negligible
Social and Community Impacts			
Economic Development/ Employment	Major Beneficial	• Promote employment of local labour.	Major Beneficial
Communicable Diseases	Moderate Adverse	• Statutory pre-employment medicals. • Access to health care for employees.	Negligible
Labour and Working Conditions			

Operational Phase Impact	Impact Significance	Mitigation Summary	Residual Impact
Human Resources policy and procedures	Minor Adverse	• Establishing HR policy and procedures for BMP in compliance with IFC PS2 requirements, including provision of a clear and understandable written statement of rights to each employee. • Applicable to employees of all contractors and suppliers. • Auditing of documents.	Negligible
Occupational Health and Safety			
Operation –General requirements	Major – Minor Adverse	• Provide appropriate PPE, e.g. hearing protection, safety glasses, respiratory protection, protective (non-flammable) clothing, rubber boots. • Prepare H&S risk assessments for all activities. • Operate a permit-to-work system. • Operate a vehicle permit system. • Training and awareness of workers regarding occupational safety issues on site. • Provision of first aid facilities together with personnel trained in its use.	Negligible
Major Accident Hazard	Major – Moderate Adverse	• General safety in design practice studies. • Operating and maintaining the equipment in accordance with operation and maintenance manuals and approved procedures. • Working to a formal H&S management system. • Implementation of an Emergency Response Plan and Oil Spill	Negligible

Operational Phase Impact	Impact Significance	Mitigation Summary	Residual Impact
		Contingency Plan.	
Crisis and Emergency Response Plan	Major – Minor Adverse	• Review of the Crisis Emergency Response Plan to include for the BMP so that the measures to limit the impact of incidents are in place.	Negligible
Oil Spill Contingency Plan	Major – Minor Adverse	• Review of the Oil Spill Contingency Plan to include for the BMP and other developments in the vicinity of Bapco operations so that the measures to limit the impact of incidents are in place.	Negligible